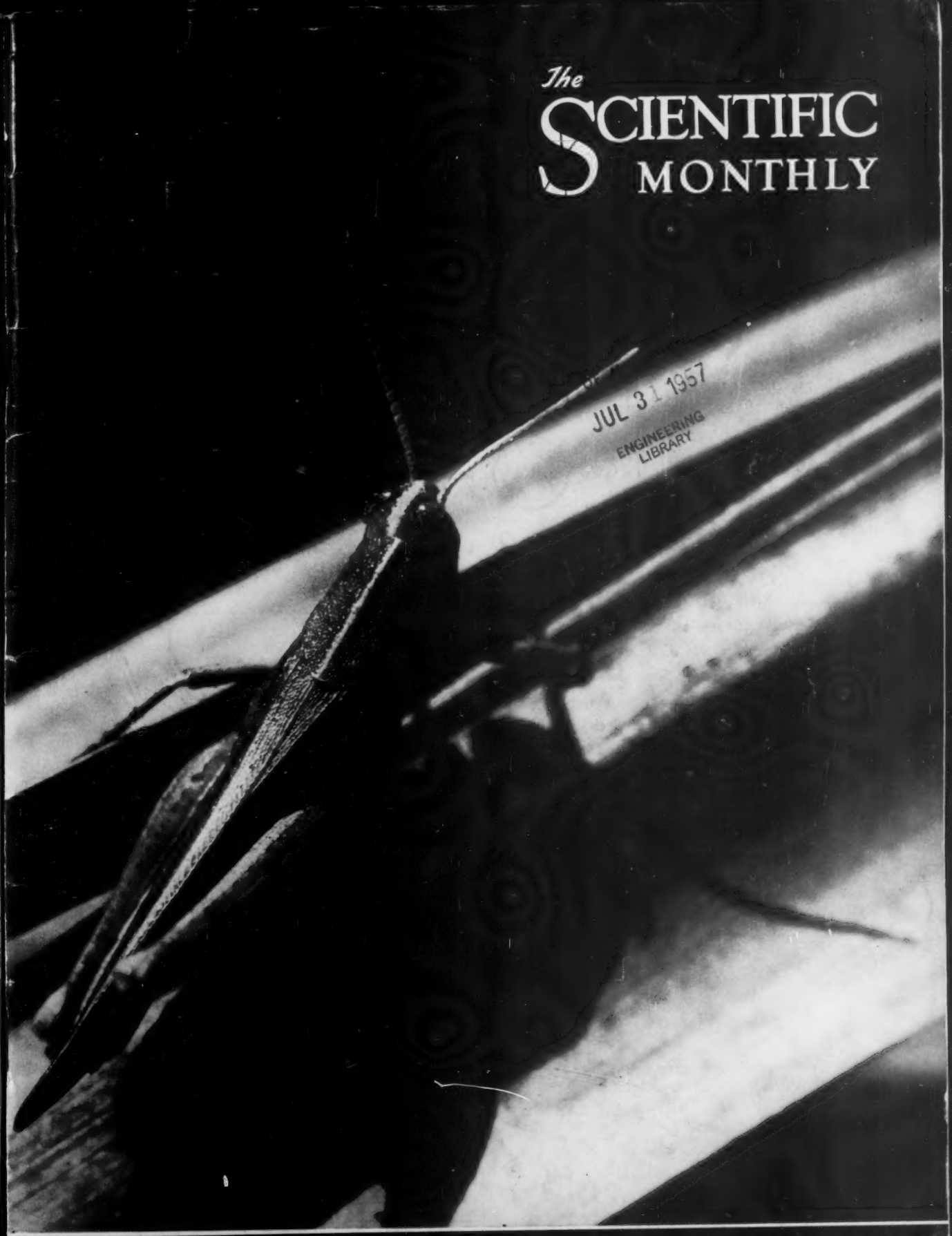
The SCIENTIFIC MONTHLY



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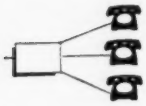
VOL. 85 NO. 2 AUGUST 1957

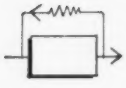
Pacemakers in the technology of our electronic age

Certain discoveries, inventions and developments of Bell Telephone Laboratories have been truly epochal in their effect upon the technology of our time. Each has come out of a single quest —a search for ways to make telephony ever better. But many have opened the way to exciting advances in TV, movies, radio, horology, astronomy. Here are ten of Bell Laboratories' contributions to the modern world.

Electronic amplifier. First high-vacuum electronic amplifier. Made possible long distance telephony and then opened the way to radio broadcasting.



Wave filter. Precisely separates bands of frequencies. Provided major key to economical sharing of the same wires by many voices or radio programs. Indispensable control tool in radio, television and radar.



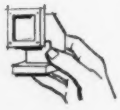
Negative feedback amplifier. Provides distortionless and stable amplification. Made possible the enormous, precisely controlled amplification needed in long distance telephone calls. The principle is now basic in amplifiers for radio, TV and high-fidelity reproduction.

Quartz crystal. Standard super-accurate quartz crystal oscillator developed for frequency controls in radiotelephony. Has also become the standard control for clocks in world's astronomical laboratories.

Coaxial cable system. Hollow tube with a central conductor was developed to transmit hundreds of voices simultaneously. Now also provides long distance carrier for TV in partnership with microwave beams.

Transistor. Tiny solid-state device uses extremely small amounts of power to amplify signals. Makes possible electronic telephone switching and much smaller hearing aids, radios, TV sets and electronic computers.

Dial system "brain and memory." Takes over your call and sees that you are connected in the best and quickest way. Newest example: Direct Distance Dialing from home telephones to any part of the nation.



Waveguide. Hollow conductor transmits high-frequency waves. From this came "pipe" circuits essential to radar and very short-wave radio communications.

Microwaves. Bell Laboratories developed long distance microwave transmission. It operates by focusing radio beams from station to station, carries cross-country telephony and TV.

Radio astronomy. This great new science began in the study of radio interference at Bell Laboratories . . with the tremendous discovery that radio waves emanate from the stars.

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VOL. 85 AUGUST 1957 NO. 2

Origin of the Amniote Egg . . . . . *Alfred S. Romer* 57

World Affairs, Languages, and Children . . . . . *Kenneth Mildenberger* 64

Origin and Use of the English Peat Fens . . . . . *Kenneth Thompson* 68

American Foreign Aid: a Reappraisal

Purposes of International Aid Programs . . . . . *H. vanBuren Cleveland* 77

Foreign Aid and the Theory of Economic Development . . . . . *Ragnar Nurske* 81

Future of American Foreign Aid . . . . . *Max F. Millikan* 86

Social Responsibility of the Physician . . . . . *H. Jack Geiger* 89

Minimum Earth Satellites as "Storm Patrol" . . . . . *S. F. Singer* 95

Association Affairs: Hotel Headquarters and Housing, Indianapolis Meeting; Junior Academies of Science 98

Book Reviews of *An Introduction to Cybernetics; The Criminal, the Judge, and the Public; Through Soviet Windows; Logic without Metaphysics; Eisame Inseln: Eine Forscherfahrt im Persian Gulf; Medical Research: a Midcentury Survey; Common Frontiers of the Social Sciences; Machine Literature Searching; The Land Called Me; Principles of Engineering Heat Transfer; Mission on the Nile; Grasslands of the Great Plains; Weather*; Books Reviewed in *Science*; New Books 101

Cover: Summer Visitor

[*Courtesy Charles Walcott, Department of Zoology, Cornell University, see page 76*]

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Science and Technology

All inquiries concerning items listed here should be addressed to The Scientific Monthly, *Room 740, 11 W. 42 St., New York 36, N.Y. Include the name(s) of the manufacturer(s) and the department number(s).*

Particle-Size Distribution Analyzer

The Micromerograph, a particle size distribution analyzer, utilizes a technique in which powder particles are dispersed in air and allowed to settle, under the action of gravity, onto a servoelectronic balance. The output is a continuous plot of the weight of powder settled against time. Application of Stokes' law to the data yields a particle-size distribution curve. A test run requires 15 minutes and about 0.1 gr of sample. Compressed nitrogen is used to inject the powder into the sedimentation tube. (Sharples Research Laboratories, Dept. M306)

Reinforced Tape

Teflon tape reinforced with finely woven glass cloth is produced in widths of ¼ in. to 12 in. and in thicknesses from 0.002 to 0.06 in. The tape can be bonded with ordinary adhesives. The cementable surface is produced by treatment with a mixture of sodium and ammonia. It is claimed that reinforcement provides greater abrasive resistance, higher tensile strength, lower cold flow, and improved dimensional stability for Teflon tape. (Continental-Diamond Fibre Corp., Dept. M309)

Spectrometer

Nuclear-radiation spectrometer consists of a linear pulse amplifier, a pulse-height analyzer, a ratemeter, and a high-voltage power supply. The pulse-height analyzer has a recovery time of 0.4 sec and covers the range of 1 to 100 v with 0.1-percent linearity and with a stability of better than 0.1 v for a 20-percent change in line voltage. An automatic scanner with scan times of 0.25, 0.5, 1, 2, and 4 hours is included as an accessory. (Mt. Sopris Instrument Corp., Dept. M334)

Chromatograph

Qualitative or quantitative separation of compounds with boiling points from 20° to 400°C may be made with a new chromatograph. The sample is injected by a 0.25-ml syringe through a silicone-rubber gasket. Temperature may be increased 2°C per minute and maintained to 1°C. Interchangeable columns and a variety of column packings are available. (Wilkens Instrument and Research, Inc., Dept. M335)

Refractory Cement

Designed to withstand temperatures between −420° and +1000°F, a refractory cement will hold metal to metal, glass, or ceramics. The adhesive is dielectric and will not crack, craze, or check even on flexing surfaces or when it is used to join materials of unequal thermal expansivity. It is also waterproof and nonhygroscopic; it is not affected by most reagents. The upper temperature limit of its usefulness can be extended to 1500°F by modification of composition. (Charles Engelhard Inc., Dept. M433)

Psychrometer

Psychrometer consists of wet- and dry-bulb thermometers and an electric fan that is powered by flashlight batteries. The instrument measures relative humidities in the range from 10 to 100 percent. (Bendix Aviation Corp., Dept. M312)

Pressure Balance

Pressure balance is rated 60,000 lb/in.^{2} with accuracy better than 1 part in 10,000, sensitivity 1 in 100,000, and reproducibility 1 in 20,000. The balance includes a measuring cylinder and piston, a piston-rotating mechanism, and a weight-carrying system. Rotation of the piston above a critical speed reduces friction to less than 1 g. Ten different cylinders are used for the range to 60,000 lb/in.^{2} Pressure measurements are made with the piston rotated by its own inertia and the motive power disengaged. (Philips Electronics, Inc., Dept. M340)

Tube Furnace

Approximately two hours are required for a tube furnace to heat to 5000°F. The heat zone is 12 in. long and 3 in. in diameter. Carbon resistors comprise the heating elements. The electrodes are water cooled. Electric interlocks shut down the furnace automatically on failure of the water supply. The furnace may be equipped with either Ignitron-Thyratron-type or saturable-reactor-type power control. (Wheeler-Kight and Gainey Inc., Dept. M346)

Current Integrator

Beam current from 1 mμa to 1 ma and accumulated charge from 15 mμcoul to 29 coul in particle accelerators may be measured with a current integrator. Accuracy is said to be ±1 percent. A preset-charge feature permits automatic stopping of the beam current when a predetermined charge has been reached. The instrument is rack mounted and contains its own power supply. (El Dorado Electronics Co., Dept. M267)

Balance

Recording balance is suitable for a total load of 100 g. For thermal work, the balance is surmounted by a nichrome-wound furnace. Furnace temperatures and loss of weight are recorded, side-by-side, on a twin-pen electronic recorder. A capacitance sensor follows the movement of the balance beam to provide observation of weight. The balance is air damped. Sensitivity may be either 1 mg or 0.1 mg. At the end of each full beam movement, a weight-loading mechanism is actuated. In this way, changes of weight up to 1 g can be followed automatically on the 1-mg sensitivity model. A single-recorder model that records weight against time is also available. (Stanton Instruments Ltd., Dept. M424)

Solar Furnace

Solar furnace provides a tool for exposing material to temperatures of 3500°C over a circular area of 0.6 cm diameter without contamination from sample containers or furnace walls. The basic component of the furnace is a parabolic mirror 60 in. in diameter. The front reflecting surface of the mirror is coated with stellite. A viewing port at the back of the reflector permits insertion of instruments. The sample can be moved in three orthogonal directions and can be tested in controlled atmospheres or in vacuum. Temperature control is accomplished by shielding. The sun can be tracked manually by sighting in a collimating tube and using sensitive potentiometers to correct the basic speed of the motors that rotate the reflector. Automatic-tracking and temperature-control devices can be furnished. (Arthur D. Little, Inc., Dept. M339)

Nuclear Power Pack

A nuclear battery which converts nuclear energy directly into electrical energy in current ratings from 5 to 5000 μa and equilibrium voltages in the order of 10 kv is the basis of a nuclear power pack that is capable of delivering energy pulses up to 337,000 ergs. The battery current is used to charge a capacitor. Means are provided to regulate capacitor voltage at values between 75 and 750 v. The power packs have a shelf or use life of 25 years. They are supplied encapsulated in metal cases provided with standard connectors. (Universal Winding Co., Dept. M353)

Silicones

A 48-page booklet entitled "Silicones in medicine and surgery" describes silicones and their physiological properties. The booklet purports to be the most thorough review of the literature of the subject ever assembled. A variety of aspects of silicones are covered, including dentistry, vial coatings, dermatology, instrument sterilization, etc. (Dow Corning Corp., Dept. M416)

Microphones

Acoustic measurements at levels exceeding 200 db above 0.0002 μbar may be made with microphones designed for both audible and ultrasonic frequencies. The microphones show linear response to extremely high magnitudes; thus they are suitable for the measurement of blast pressures and shock waves as well as for conventional sound pressure levels. Models are available for frequencies up to 120 kcy/sec. (Massa Laboratories Inc., Dept. M419)

Range Finder

Distances from 8 to 100 ft may be measured to a reported accuracy of ± 2 percent with a range finder of 6-in. base length. Operation is based on coincidence of two images, one seen in natural color and the other in a contrasted gold color. The instrument is adjusted to cause the two images to coincide, and the distance is read on the adjustment dial. (Edmund Scientific Co., Dept. M428)

Oscilloscope

The sweep of an oscilloscope that covers the frequency range from direct current to beyond 50 Mcy/sec can be driven at repetition rates as high as 250 kcy/sec and as slowly as 0.02 sec/cm. The y-axis amplifier is a three-stage direct-coupled type. Other features include a pulse rise time of 7 mμsec, attenuator ranges from 0.2 to 200 v full scale and an a.c.-d.c. synchronizing circuit which permits selection of the portion of the synchronizing signal from which to trigger the sweep. The oscilloscope is built up of six interchangeable units to provide versatility. All operating voltages are regulated. (Allen B. DuMont Laboratories, Inc., Dept. M359)

Electrophoresis Cell

Continuous separation of protein fractions—for example gamma globulin from blood—may be made with an electrophoresis cell. The cell is constructed of plastic and semipermeable membranes. In operation, the cell, immersed in buffer solution, is subjected to a direct current and fed continuously with the protein solution to be fractionated. Products of the separation are continuously withdrawn. (Perkin-Elmer Corp., Dept. M418)

Relative Humidity Chamber

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Seismograph

A portable seismograph manufactured by Hilger and Watts, Ltd., records for 24 hr at a rate of 60 mm/min. The seismometer elements are of the moving-coil type with permanent magnetic field. Natural period is 1 sec in both the vertical and horizontal positions. The unit is sealed in a metal case to permit burying it in open ground. Ground movements on the order of 10^{-7} cm can be detected. The recorder, of the photographic drum type, can accommodate three seismometers. (Jarrell-Ash Co., Dept. M456)

Hygrometer

Electrolytic hygrometer automatically and continuously measures water concentration in vapor samples with 5 percent accuracy in the 0- to 1000-ppm range. The measurement is made by passing the sample-gas stream through an analytic element that absorbs and electrolyzes water present in the stream. The electrolysis current is a measure of the rate of absorption of water. The instrument will measure samples at temperature up to 100°C. An incorporated alarm system can be set at any point in the instrument's range. Output will operate a 10 or 50 mv recorder. (Beckman Instruments, Inc., Dept. M434)

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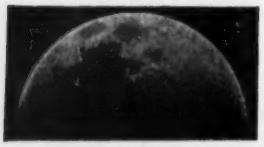

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THE
SCIENTIFIC MONTHLY

AUGUST 1957

Origin of the Amniote Egg

ALFRED S. ROMER

Dr. Romer is director of the Museum of Comparative Zoology and Alexander Agassiz professor of zoology at Harvard University. He was graduated from Amherst College in 1917 and received his Ph.D. degree from Columbia University in 1921 and an honorary degree of doctor of science from Harvard in 1949. He was an instructor in anatomy at Bellevue Medical College (New York University), a staff member of the American Museum of Natural History, and was professor of vertebrate paleontology at the University of Chicago prior to his appointment to the Harvard faculty, in 1934. Dr. Romer was awarded the Mary Clark Thompson medal of the National Academy of Sciences for 1954.

ONE of the most important steps in the evolution of vertebrates was the "invention" of the amniote egg, which, with associated developmental processes, is characteristic of the higher vertebrate classes. Its appearance marks the beginnings of the history of the reptiles and the potentialities of evolution of the great groups that are dominant today, the birds and mammals. The evolution of the amniote type of development was a necessary antecedent to the true conquest of the land.

Amphibian versus Reptilian Reproduction

As it is seen today on the breakfast table, the amniote egg is a familiar, commonplace, and hence seemingly prosaic object. It is, however, marvelously well adapted for the reproduction of terrestrial animal types and permits a developmental history of quite a different sort from that found in lower vertebrates. Among fishes, the eggs are laid in the water, and the resulting young remain there as persistently gill-breathing water-dwellers.

The amphibians (of which the frogs, toads, newts, and salamanders are the common modern types) developed limbs, and thus the ability to walk abroad upon the land, many millions of years ago, in Paleozoic times (Fig. 1). But even today, the most familiar North Temperate Zone representatives of that group have hardly changed a whit in their reproductive processes. No matter how far common frogs, toads, or newts may have wandered during the year, every spring sees them returning to ponds and streams. There they lay unprotected clusters or strings of eggs similar to those of their fish ancestors. There is little nourishing yolk in this typical amphibian egg, and consequently the tiny creature which hatches from it must, from an early stage, be highly adapted to an active, food-seeking life as a water-dwelling, gill-breathing, essentially fishlike larva. After a considerable period of feeding and growth, there takes place a radical change in structure and mode of life—a change which is most strikingly seen in the rapid metamorphosis of tadpole into frog or toad. Gills atrophy; lungs expand, and air takes the place of water as an oxygen source; the tail fin is reduced; legs develop, and the amphibian is freed to walk out onto the land.

This necessity of leading a "double life" is a serious handicap to the development of the individual; it must, at successive stages, be structurally and

functionally fitted for two very different modes of life and, in consequence, falls far short of perfection in adaptation for either. And even if the end-product is a terrestrial, or potentially terrestrial, adult, the release from the water is never complete, for every spring the typical amphibian must return to its natal element to deposit eggs and initiate the next life-cycle. Such an amphibian is bound to the water; its release is never complete.

Quite in contrast (Figs. 2, 3) is the mode of reproduction seen in typical reptiles (and in birds and the most primitive mammals as well). The amniote egg can be laid on land; neither young nor adult need ever enter the water. The young amphibian must be prepared to make its own living while still of very small size; the amniote egg is richly supplied with nutritious yolk, which enables the young to attain considerable growth before birth. If they were exposed to air, the delicate tissues of a developing embryo would be subject to fatal desiccation; early in its development the amniote embryo is surrounded by a continuous membrane, the amnion (to which this developmental type owes its name).

Within the liquid-filled amniotic sac, the developing embryo is in a miniature replica of its ancestral pond. Protection against mechanical injury is afforded by the shell. Extending out from the body of the embryo is a sac—the allantois—which expands beneath the shell and serves two further vital functions. The growing embryo, in which metabolic processes are proceeding at a rapid rate, must breathe. The shell is porous; the allantois beneath it forms an embryonic lung, receiving oxygen from the air and giving off carbon dioxide waste. A result of the rapid metabolism of the growing embryo is the accumulation of nitrogenous waste—an embryonic urine which must be stored, until hatching, within the compass of the egg. The cavity of the allantois also serves this purpose, acting as a temporary bladder.

As a result of this complex but efficient series of amniote adaptations, the animal is completely freed from an aquatic life. No longer is the adult compelled to return to the water for reproductive purposes. The young, within the protection of its shell and membranes, is freed from the necessity of undergoing a fishlike larval life; nourished by the abundant yolk, it can hatch directly as a vigorous little replica of its parent, fully and directly equipped for terrestrial existence.

Once this new amniote pattern of development had evolved, in Upper Paleozoic days (*1*), there began the great radiation of reptiles that is characteristic of the Mesozoic "Age of Reptiles," during which period the relatively unprogressive amphibians were reduced to their present insignificance. And from this reptilian radiation there presently emerged the still more progressive lines which gave rise to the birds and mammals. As far as can be told from the fossil record, the adult structure of the very earliest reptiles showed little if any advance over that of their amphibian relatives and contemporaries. It was solely owing to the amniote mode of development that the evolution of higher vertebrates was made possible.

Aquatic Nature of the Oldest Amniotes

How, when, at what stage did this crucial reproductive improvement appear? The story once seemed clear to me, in a form in which I told it to many a student audience. Well before the close of the Carboniferous period, the fossil record shows us, there had appeared advanced amphibian types with well-developed limbs and other features indicating that, as adults, they could be, and were, mainly terrestrial forms rather than water-dwellers. A sole obstacle lay in the path of their conquest of the land—their mode of development, through which they were chained to the water (a lovely and dramatic phrase!). At long last there came the final

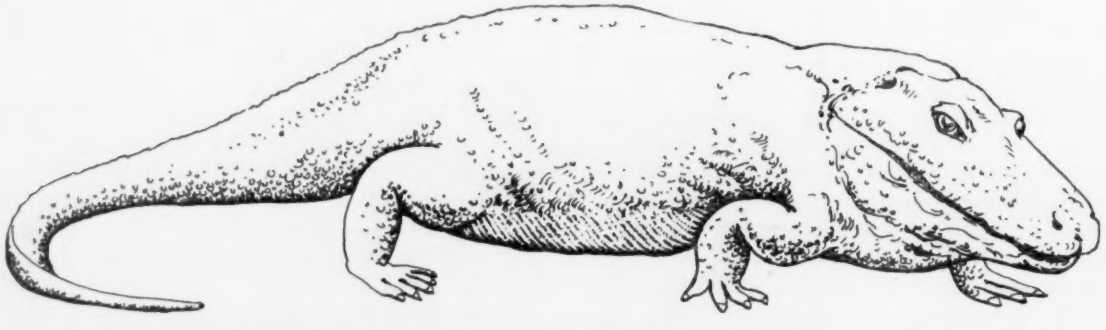

Fig. 1. *Eryops*, an example of a Paleozoic amphibian well equipped for terrestrial life, which quite surely reproduced in typical amphibian fashion.

stage in their release—the development of the terrestrial amniote egg. Their bonds were broken, and, as true terrestrial forms, the early reptiles swept on to a conquest of the earth!

This is a fine story. However, I now suspect that it is far from the truth. It assumes that the *adult* first became a land-dweller and that terrestrial reproduction was a later development. It now seems to me more probable that the reverse was the case—that the *egg* came ashore first and that the adult tardily followed.

My skepticism arose from a study of the oldest adequately known reptilian faunas, those of the early part of the Permian period. Some years ago I restudied the remains of *Limnoscelis palustris* (Fig. 4) from the Permian of New Mexico (*2*). This is quite surely a reptile, although a very primitive one, with a terrestrial amniote mode of reproduction. But the adult was, quite certainly, far from being a fully developed land-dweller. Williston (as can be seen by the scientific names he applied to the animal) was impressed, as I was later, by the fact that its habitat appears to have been essentially aquatic. Can this have been a reversion from the purely terrestrial existence which we had assumed to be characteristic of the ancestral reptiles? This is very doubtful. *Limnoscelis* is such an early and primitive reptile that it is much more probable that its ancestors had never abandoned an aquatic life. *Limnoscelis* surely laid its eggs ashore, but the adult, it appears, still remained happily in its ancestral waters.

Still stronger skepticism is induced by a study of Permian pelycosaurs (*3*). This group consists of early forms which are not merely reptiles but reptiles that are already separated from other major lines and on the way to becoming the ancestors of mammals. Here, in this progressive group, one would think that we would be dealing with purely terrestrial amniotes. Some pelycosaurs are reptiles of this nature. But the more primitive pelycosaurs (of which *Ophiacodon*, Fig. 5, is best known) were not, to any degree, terrestrial. They were aquatic fish-eaters; they possessed limbs which would enable them to climb the banks, but their home, like that of their amphibian and fish ancestors, lay in the Permian streams and ponds.

Can this be a secondary reversion to the water? Again (as in the case of *Limnoscelis*), this is highly improbable. This type of pelycosaur is known well back into the Carboniferous period, and the only obvious conclusion from the facts is that, despite the phylogenetic position of these pelycosaurs—well advanced up one major branch of the reptilian family tree—they had never left the water.

The fossil evidence, then, strongly suggests that, although the terrestrial egg-laying habit evolved at the beginning of reptilian evolution, adult reptiles at that stage were still essentially aquatic forms, and many remained aquatic or amphibious long after the amniote egg opened up to them the

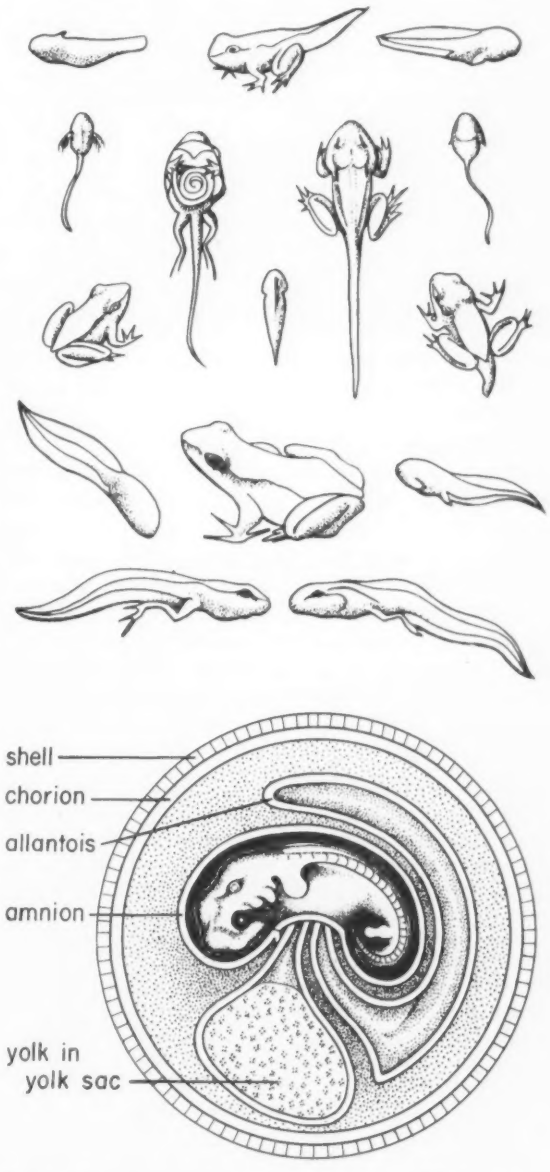

Fig. 2. The classic contrast. (Top) A simplified version of the familiar Leuckhart wall chart, as it appears in many a textbook, showing the "typical" amphibian mode of development through a series of water-dwelling tadpole stages to final metamorphosis into an adult frog. (Bottom) Diagrammatic representation of the development of an amniote egg, which shows the growing embryo protected by shell, chorion, and amnion, supplied with an embryonic lung (the allantois), and a food supply of yolk.

Fig. 3. The oldest known amniote egg, from the Lower Permian of Texas.

full potentialities of terrestrial existence (*4*). It was the egg which came ashore first; the adult followed.

Why the Amniote Egg?

If we accept this as a reasonable conclusion from the paleontological evidence, we are, nevertheless, faced with a major puzzle. In the light of the earlier point of view, one could readily account for the success of the amniote type of development as being strongly favored by selective process in animals which were otherwise terrestrial in habits. But what strong advantage could there be in terrestrial embryonic development in the case of forms which were still aquatic or, at the most, amphibious in adult life?

To attempt a solution, let us review reproduction in modern amphibians. I have cited the reproductive habits of familiar North Temperate frogs, toads, and newts. But if we examine the developmental histories of the modern orders as a whole—and particularly the varied tropical anurans—we gain quite another picture. The fishlike mode of development I have described is, to be sure, primitive, but so many modern amphibians have departed from it that it can hardly be regarded as typical of the group as a whole.

In a large proportion of modern forms, the eggs are not laid in the water in ancestral fashion. In fact, these amphibians may go to any extreme to avoid this (*5*). The eggs may be laid on the bank near the water, under logs or stones or in a cavity in the earth, in a hollow stump, or in a "nest" of leaves in a tree. They may be carried about on land, placed in pockets on the back of one or the other parent, kept (curiously) in the vocal pouch of the male, or, in the case of the "obstetrical toad," wrapped clumsily around the father's legs.

The "typical" amphibian egg, like that of the fish ancestors, is small in size, with only a modest amount of yolk, and, except for the presence of a surrounding jelly, there is no development of membranes or other protective devices for the embryo. This is quite in contrast to the amniote egg; but, in one modern amphibian or another, we find a variety of modifications which parallel those of amniotes in most respects. In some instances the amount of yolk is greatly increased, the developing embryo is perched above a distended yolk sac, much as in an amniote, and the necessity of larval feeding is done away with. There is no expansion of an allantoic "bladder" to function as a lung, but comparable air-breathing organs may be formed by expansion of a highly vascular tail or by the development of broad, thin sheets of superficial tissue extending out from the gill region. There is no development of a complete amnion as a protection against desiccation, but in some forms there is a nearly complete covering of the embryo by somewhat comparable sheets of tissue. In fact, the only amniote structure that is not paralleled is the shell—a relatively minor part of the whole complex.

In sum, many modern amphibians have developed, to varied degrees and in varied fashion, adaptations which, like those of amniotes, tend to reduce or eliminate the water-dwelling larval stage.

Fig. 4. *Limnoscelis*, a primitive reptile which was contemporaneous with amphibians such as *Eryops* and was still amphibious in habits but which had quite surely attained the amniote type of development.

What is the significance of this series of adaptations? Not any "urge" toward a purely terrestrial existence, for the amphibians which show these trends toward direct development are as varied in adult habits as are amphibians as a whole.

There appear to be two major advantages. (i) Eggs and young in a pond form a tempting food supply, an amphibian "caviar," open to attack by a variety of hungry animals, ranging from insects to other vertebrates; furthermore, the larvae are in heavy competition for food with other small water-dwellers. If eggs are laid in less obvious places, the chance of survival is greatly increased; if guarded or carried by a parent, they are under protection. (ii) In some regions there are annual dry seasons, when the ponds and pools in which "normal" amphibians would lay their eggs tend to dry up. Reduction or elimination of the water stage increases the chances of survival of the young, which might be destroyed if they were living as tadpoles in a drying pond.

May not the amniote type of development have been similarly evolved to gain some immediate advantage rather than as any sort of "preadaptation" for land life? For modern amphibians, protection of the eggs from enemies is by far the more important of the two major advantages that are gained by changes in reproductive methods (although, in certain instances, adaptations which shorten larval life appear to be related to protection against potential drouth conditions). For the Paleozoic reptile ancestors, the reverse was probably the case. Potential egg devourers were then presumably less abundant, but danger of desiccation was far greater.

Today there are only limited regions of the tropics in which the annual weather cycle is one of seasons of heavy rains alternating with drouths. But as Barrell first pointed out, large areas of the earth in late Paleozoic days appear to have been subject to marked seasonal drouth (the presence of numerous red-bed deposits in the Upper Paleozoic appears to be correlated in great measure with drouth phenomena). Under such conditions, the life of the amphibious vertebrates of the day was a hazardous one. Particularly hazardous was the developmental process. If the old-fashioned methods were retained, and the young must, perforce, spend a long period of time as gill-breathing larvae, they were in grave danger of being overtaken by the oncoming of the rainless season and of being killed in their drying natal ponds. Any reproductive improvement which would reduce or eliminate this danger had a strong survival value. It is probable that various essays in this direction were made. The one truly successful one was that which led to the development of the amniote egg and the resultant origin of the reptiles, which, from that time on, became increasingly successful over their less progressive amphibian relatives. Today, a variety of amphibians are struggling (so to speak) to attain some type of development comparable to that which the reptile ancestors achieved eons ago, but their efforts are too little and too late.

Deductions from the study of climatic history are thus consonant with the facts of the fossil record. The fine story of the reptile ancestor as an animal which had become fully terrestrial in adult life and needed only, as a final step, to improve its reproductive habits in order to conquer the earth is, apparently, pure myth. It was the egg which came ashore first; the adult followed later.

We may picture the ancestral reptile type as merely one among a variety of amphibious dwellers in the streams of late Paleozoic days. All were basically water-dwellers. All, alike, found their living in the water, with fishes and invertebrates as the food supply, for there was, at first, little animal life on land to tempt them. In most respects the early reptile had no advantage over its amphibian contemporaries. Only in its new type of development was the reptile better off. This advantage, however, did not at first imply the necessity of any trend toward increased adult life on land. And it was only slowly, toward the close of the Paleozoic Era, that many (but not all) of the reptiles took advantage of the new opportunities which amniote development offered them and became terrestrial types, initiating the major evolutionary reptilian radiation in the Mesozoic—the Age of Reptiles. This potentiality of conquest of the earth by the reptiles was not the result of "design." Rather, it was the result of a happy accident—the further utilization of potentialities that had been attained as an adaptation of immediate value to their amphibious ancestors.

Fig. 5. *Ophiacodon,* an early reptile with amniote development, which had already advanced in certain respects toward the mammals but was still essentially a water-dweller.

Teleology and Tetrapod Evolution

It is sometimes said that the evolution of terrestrial vertebrates from fish ancestors cannot be explained by purely natural processes. How, it is asked, could there have been effected in the ancestral fish the whole series of structural and functional changes which were necessary for a successful existence on land but which appear to have been of no immediate value to the animal in its piscine existence? How could these changes have occurred unless there were some supernatural directive force behind the process, some mysterious "urge" that made for "preadaptation"? So runs the argument, for example, in that recent popular work, *Human Destiny,* by Lecomte du Noüy.

In this case, as in other cases where the evolutionary history seems so complex that natural explanations seem at first to be improbable, the story can, I think, be explained on quite natural grounds, with involvement of only the simplest of recognized evolutionary principles—selection for characters that are immediately useful to the animal in its actual environment without reference to their possible use in some future mode of life.

The complete transition from water to land involves a long series of structural and functional changes. For present purposes, however, we may select three of the most striking and outstanding changes that are necessary to enable a fish ancestor to become a successful terrestrial animal: (i) the development of lungs for air-breathing; (ii) the development, from fish fins, of limbs capable of supporting it on land; and (iii) the development (as discussed earlier in this article) of a type of egg which will free the reproductive processes from the water.

How could these changes be of use to a water-dweller? The clue, I believe, lies largely in the environmental factor already noted—widespread seasonal drouth in late Paleozoic times. Let us discuss these three factors in turn.

Lungs. We think of lungs as essentially characteristic of land animals. What need does a fish, breathing with gills, have for such structures? Today there are only a very few fish which possess lungs, and one tends to assume from this fact that lung-bearing fishes are merely "poor relations" of the land vertebrates, back eddies in the stream of evolution, and that lungs, here, have little meaning.

But this is not at all the case. If we look into the life and habits of these fishes, we find that lungs are highly advantageous in the peculiar conditions under which they live. Three of them are members of the lungfish group proper—the Dipnoi, one genus each being found in Australia, Africa, and South America. The others (*Polypterus* and a relative) are African members of quite another series of bony fishes—the Actinopterygii, or ray-finned fishes—but differ from the normal members of this group in possessing lungs. All five are tropical forms, and, more particularly, all live in regions of seasonal drouth. In such areas, lungs are of no advantage in the rainy season. But when the rains cease, the streams slow down and cease running, the remaining ponds and pools become stagnant, with a lowered oxygen content, and the situation is very different.

Ordinary fishes, which depend on gill-breathing for their oxygen supply, die in enormous numbers in drouth conditions and can continue to survive as species only because the few survivors spawn large numbers of young, which can soon restore the populations. In the case of the lung-bearing fishes, which lay a relatively modest number of eggs, survival of the individual is more important. It is the presence of lungs which enables the fish to survive, for, in default of sufficient oxygen in the water, it can rise to the surface and take in a supply of atmospheric oxygen.

Lungs, then, may be highly useful to a fish—*as* a fish—under drouth conditions. And, as I have said, such drouth conditions appear to have been exceedingly common in late Paleozoic times, including the Devonian period, when fish evolution first attained a high degree of development and amphibian evolution began. Under such circumstances, we would expect that—quite in contrast to present times—lung-bearing fishes would have abounded in Devonian fresh waters. This was definitely the case.

The higher bony fishes are (and were then) arrayed in three major subdivisions—lungfishes, or Dipnoi; Crossopterygii, the group from which the land vertebrates are derived; and the Actinopterygii, the ray-finned fishes that are dominant today. The Devonian dipnoans were, quite surely, lung-bearing, as are their modern descendants. The crossopterygians also unquestionably had lungs (*6*). These two groups made up the greater part of the Devonian bony fish population. The ray-finned forms, most of which today lack lungs, were then insignificant in numbers, but it is possible that even in this case lungs were present in their Devonian representatives, for they are retained in *Polypterus,* a primitive living member of this group.

But for lung-bearing fishes in the Devonian, we need not stop with a consideration of the higher bony types. Much of the remainder of the fish population of the time was comprised of members of the Placodermi, a primitive fish group that is now quite extinct. It is difficult to discover the nature of the soft structures of fossil forms, but in the one placoderm in which exceptional preservation has

revealed internal structures, it was found, surprisingly, that even this lowly type of ancient fish was a lung-breather (*7*).

Lungs in fishes are today the exception. In Devonian fresh waters, lung-bearing was the rule; lungless forms were in a strong minority. In such a typical Devonian fish deposit as that at Scaumenac Bay, Canada, at least 95 percent—and probably more—of the specimens in a collection will be found to be lung-bearers. These fishes were not air-breathers because of any mysterious preadaptation or "predetermination" toward land. Under drouth conditions, lungs were structures of immediate and vital importance to them as fish.

Limbs. How can limbs of a terrestrial type be of use to a fish? The answer (which was first suggested by Watson, and on which I have later elaborated) is the seemingly paradoxical one that fishes ancestral to amphibians came to walk on land so that they could continue to live in the water.

Devonian drouth is, again, the clue to the situation. We find, in many late Paleozoic fresh-water deposits, remains of amphibians intermingled with those of the Crossopterygii. Many of the amphibians led much the same sort of life as did their fish relatives. Like them, they were carnivores, making a living on smaller fishes and invertebrates. The amphibians, like the fishes, normally lived in the water; for, in early days, there was little suitable food on land. Under "normal" conditions the fish was rather better adapted to its existence than was the amphibian, whose limbs were actually a bit of a hindrance in swimming. If drouth conditions arose, the fish was still under no handicap, for, if the water became stagnant, the fish could come to the surface for oxygen as readily as the amphibian.

But if conditions became still worse, if the pool in which these animals lived dried up completely, what then? The fish would be, quite literally, stuck—immobilized in the mud and doomed to death if the water did not soon return. At this point, limbs show their advantage. For the amphibian could leave the drying pool, could crawl, slowly and painfully, up or down the stream bed, find some pool that had not dried up, and enter it to resume its normal life in the water (*8*).

Limbs, to an early amphibian, were quite surely not a mysterious preadaptation for a life on land; such an existence, in the first stages of limb development, was (so to speak) the last thing it thought of or desired. Limbs were an immediately useful adaptation for life in the water; only gradually, as a terrestrial food supply developed, would the amphibians take advantage of the potentialities of becoming land-dwellers.

The land egg. The preceding discussion has, I hope, been sufficient to show that we do not have to account for the origin of the amniote egg by assuming any sort of mysterious "urge" toward a more completely terrestrial existence. For an amphibious animal capable of emerging onto land, laying eggs safely ashore would be immediately advantageous.

We have thus seen that some of the most prominent characteristics of land vertebrates can be accounted for as a series of adaptations that were of practical advantage as soon as they were acquired, while the animal was still partially or even entirely aquatic in its mode of life. The entire major evolutionary progression from fish, through amphibian, to terrestrial reptile—seemingly mysterious—can be interpreted in simple, natural terms. And it is probable that many another evolutionary development which appears difficult to understand without the introduction of teleology will likewise prove, when sufficiently investigated and studied, to be interpretable in the accepted framework of current evolutionary theory.

References and Notes

1. Collections of the Museum of Comparative Zoology at Harvard College, Cambridge, Mass., contain remains of the oldest fossil amniote egg (Fig. 3), a rather battered-looking shell, from early Permian rocks, about twice the age of the famous dinosaur eggs. It was laid by one of the archaic reptile types then recently evolved, but by which one of them we cannot, of course, say. The egg was x-rayed in the wistful hope that it might reveal an embryo. Because of the considerable amount of iron that it contained, it was necessary to use a powerful instrument, ordinarily used for testing armor plate, to penetrate it. As might have been expected, the x-ray plate showed nothing at all; had it not been addled, the egg would probably have hatched, and the shell would have been destroyed in the process.
2. S. W. Williston, *Am. J. Sci.* **31**, 378 (1911) and **34**, 457 (1912); A. S. Romer, *ibid.*, **244**, 149 (1946).
3. A. S. Romer and L. I. Price, *Geol. Soc. Amer. Spec. Paper* 28 (1940), pp. 172–173.
4. It is generally assumed that the great marine reptiles of the Mesozoic—the ichthyosaurs and plesiosaurs—and the amphibious-to-aquatic chelonians were descended from the terrestrial ancestors. It is, however, quite possible that these ancestors had never fully abandoned water-dwelling and that this "reversion" was but a partial one.
5. Many of the adaptations noted here are described by G. K. Noble, *The Biology of the Amphibia* (New York, 1931); see also B. Lutz, *Copeia* **4**, 242 (1947) and *Evolution* **2**, 29 (1948); G. L. Orton, *Ann. Carnegie Museum* **31**, 257 (1949).
6. J. Millot, *Nature* **174**, 426 (1954). It is of interest to note that the sole living crossopterygian, *Latimeria*, still retains vestigial lungs, although it has shifted from fresh waters to the deep sea, where lungs are now functionless.
7. R. H. Denison, *J. Paleontol.* **15**, 553 (1941).
8. For various recent emendations and elaborations of this suggestion, see C. J. Goin and O. B. Goin, *Evolution* **10**, 440 (1956).

World Affairs, Languages, and Children

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TODAY, foreign languages are being taught in the public elementary schools (below grade 7) of about 500 cities and towns, spread throughout every state in the nation. The last full survey, made in 1955, revealed that the number of children involved (more than 270,000) exceeded one-third of the enrollment in modern foreign languages in all our public high schools and was approximately equal to the number of students studying modern foreign languages in all the colleges and universities (*1*). Frequently, these ventures are small and experimental, but many of them are growing to be full-fledged programs. When one considers the obstacles, it is a miracle that this movement ever started and a wonder that it grows. Five years ago, teaching materials were few and practically unobtainable; theory and methods of teaching languages to small children were almost unknown; Americans had a long, unhappy history of distaste for foreign languages; and public education was face-to-face with elementary problems of finances, lack of school space, and shortages of regular teachers, let alone teachers of foreign languages for elementary schools! Nevertheless, between January 1953 and January 1956, the number of cities and towns with language classes in the lower grades increased by 500 percent, and each term others initiate classes. Why this phenomenal interest?

Modern Life Affects Educational Traditions

The obvious answer is that this movement reflects a basic need in our society, a need created by the era in which we live, for science has placed our nation in a role of world ascendancy and, at the same time, has telescoped distance so that no place and no person on the globe is more than 24 hours away from us. Industrially, we have the resources and the technology to produce an abundance that demands markets abroad; the annual value of our foreign trade, including goods and services, has risen from less than $4 billion in 1914 to well over $42 billion today. Financially, we have tremendous excess capital for foreign investment; by the end of 1955, private investment abroad had topped $29 billion, an increase of $2.5 billion over the previous year. In warfare, we have awesome engines of destruction that make the prospect of a major war dreadful and repugnant to all. Thermonuclear weapons, intercontinental missiles, globe-circling jet bombers, biological plagues—the modern arsenal is appalling, especially since we have no monopoly on the contents. Politically, the total impact of these factors places us in a dominant world position, whether or not we like it, while all the peoples of the earth eye us with suspicion or hope. We come to the front in the various agencies of the United Nations; we find it essential to our well-being to budget vast sums of foreign aid and technical assistance under the International Cooperation Administration and to take the initiative in the Organization of American States, in the North Atlantic Treaty Organization, in the Southeast Asia Treaty Organization, and now in the Near East.

The prosperity of our citizens has brought new leisure, and the swift flight of DC-7's and Constellations—with 4-jet transports now on the production lines—means a vacation abroad for great numbers of them. From 1947 through 1955, the Passport Office of the U.S. Department of State issued 3,064,704 passports, and from 1951 through 1954, Mexico (where passports are not needed) issued tourist cards to 1,703,438 United States citizens. All of these things add up to a pervasive world-awareness in American society. It is not limited to the salesman abroad, the diplomat, the overseas

soldier, the exchange professor, the vacationing junior executive and family—it is flowing daily into the living room on Maple Street through the newspaper, radio, and television (*2*).

With this awareness comes the inevitable realization that we, and the generations of Americans to follow us, must seek understanding of other peoples of this globe. And an essential feature of this understanding must be acquaintance with one or more foreign languages. Indeed, the future welfare of our people will depend heavily on the attitudes and skills associated with learning a foreign language.

James B. Conant has said (*3*): "Within a decade this nation has been thrust into a position of enormous responsibility in a highly uncomfortable new world. . . . Does the American tradition in education now approaching the respectable age of 100 years stand in need of modification to meet the challenge of our new world—the constricted globe of the mid-20th century? My answer would be an emphatic yes. . . . We need for the first time in our history a very large number of highly competent men and women with talents and tastes for work with people of foreign lands. We shall need to discover such people at an earlier age and provide the educational opportunities for their development. This in part is a question of acquiring skills —the command of foreign tongues—but also the development of an interest in other lands and peoples, all of which means a vast amount of hard work, of long hours of study, of patient labor with the printed as well as the spoken word."

The new role of foreign languages will result in considerable modification in American education, for during the past 40 years the teaching of languages has declined steadily. In 1915, languages held a relatively strong position; 35.9 percent of the public secondary-school population was enrolled in modern foreign languages, and most colleges had language entrance requirements. But a steady drop in modern-language enrollments began with World War I, and the figure had fallen to 19.5 percent in 1934 and to 13.7 percent in 1949 (*4*). In 1954–55 only 43.6 percent of the public high schools offered a course in at least one modern foreign language (*5*). Faced with such a situation, colleges in the years between World Wars I and II were forced, in many instances, to abandon entrance requirements in languages (in 1956 only 30.6 percent required a foreign language from freshmen entering the bachelor of arts program) and to specialize in elementary courses instead of building on secondary-school preparation (*6*). Since most high schools with language courses offered only 2 years, emphasis was placed on what seemed most attainable in that period—on reading, through grammar analysis and translation. On reaching college, many of these students felt so insecure that they decided it would be discreet to take up a different language; hence, they, too, swelled the classes of beginners. And there the thoroughly disenchanted student found himself in another 2-year course of grammar and translation. In all of this the foreign-language teacher was the unfortunate victim, for there was simply not enough time allowed in the curriculum for effective language instruction, whether the objective was reading or speaking.

New Language Approach

Into this setting was introduced the idea of beginning a second language in elementary school. Actually, it was not a new idea. In the second half of the 19th century, German, especially, was popular in the lower grades of more than a dozen cities where there were many German immigrants (*7*). But World War I ended that. Between wars, language instruction barely survived, in some private schools and a handful of public schools, and the usual language was French. With the outbreak of World War II, our government promoted "inter-American solidarity." This included more study of Spanish. A number of cities, particularly in Florida and the Southwest, initiated Spanish programs in the grades, but most of these were soon victims of demobilization when the war ended.

The real beginning of the present movement came on 3 May 1952, when the U.S. Commissioner of Education, Earl J. McGrath, at his own request, spoke to a meeting of language teachers in St. Louis. After calling attention to the new role of the United States in world affairs, he said (*8*): "Only through the ability to use another language even modestly can one really become conscious of the full meaning of being a member of another nationality or cultural group. It is in our national interest to give as many of our citizens as possible the opportunity to gain these cultural insights. . . . Only a small percentage of American children have an opportunity to begin the study or use of a language other than their own before they enter high school. Yet it is a psychological fact that young children learn new languages easily and idiomatically. . . . [I propose] that there be a complete reconsideration of the place of foreign-language study in American elementary education. Such a reappraisal, I should hope, would lead to the offering of foreign language at least on an optional basis in many of our schools beginning in the fourth, fifth, or sixth grades. . . . This is a matter which deserves

the earnest consideration of all members of the academic profession and of all laymen as well." The following January, McGrath convened, in Washington, D.C., the Conference on the Role of Foreign Languages in American Schools (*9*), at which nearly 350 educators discussed the problems of introducing languages in the elementary school.

It soon became apparent that many persons were willing to give McGrath's proposal earnest consideration. By the fall term of 1955, Spanish was being taught to 221,583 public elementary-school pupils in 203 cities and towns; French, to 46,849 pupils in 192 communities; German, to 2481 pupils in 40 communities; and there were scattered instances of the teaching of Latin, Italian, Norwegian, modern Greek, Swedish, and Japanese. Excellent materials and teachers' guides have been developed, and each summer about 30 colleges and universities sponsor workshops for teachers of foreign languages in the elementary school.

How It Works

Most of these programs in the grades are still highly exploratory, and they differ considerably in the details of their approach. But two types seem to be emerging, and nearly all are variants of one of these basic plans. The first we may label "type A." It usually begins early—not later than the third grade—and progresses through the elementary school. The emphasis is on intensive but pleasurable experience in the use of the new language—that is, on listening comprehension and speaking, for the first 2 years or so. Reading is not started until the child has an easy familiarity with the spoken language; writing comes last. Grammar is never presented as such; the pupil absorbs it inductively, as he did that of his native tongue. Sessions of 15 or 20 minutes are held at regular times, usually daily. The teacher is a specialist, skilled in the spoken language, who visits a number of classes each day. By the time the pupil finishes grade 6, he should be reasonably well grounded in the spoken tongue. In grade 7 he is ready for more formal work in reading, but conversation continues to be a regular part of his language experience. This kind of program is in effect in Fairfield, Connecticut, in Somerville and Hackensack, New Jersey, and in El Paso, Texas.

The "type B" program differs in a very basic way—instruction in the foreign language is the responsibility mainly of the classroom teacher rather than of a specialist. Since few classroom teachers have competence in a foreign language, auxiliary means must be used to enable the children to hear and imitate the authentic, spoken tongue. In San Diego, California, special magnetic tapes are prepared, to be played in the classroom; in Dade County, Florida, the educational radio station broadcasts lessons into the classrooms and, after school, into the homes; and in Schenectady, New York, a weekly television lesson is an essential feature of the program.

Teachers of languages in elementary schools are enthusiastic about the results, especially if they have had previous experience at the high-school or college levels. The scientific validity of an early start in language-learning has been indicated by the neurologists Wilder Penfield and Lamar Roberts, who have stated (*10*): "The optimum age for *beginning* the continuous learning of a second language seems to fall within the span of ages 4 through 8, with superior performance to be anticipated at ages 8, 9, 10. In this early period, the brain seems to have the greatest plasticity and specialized capacity needed for acquiring speech. The specialized capacity includes the ability to mimic accurately the stream of speech (sounds, rhythm, intonation, stress, and so forth) and to learn and manipulate language patterns easily. Support for the conviction that the brain has greater plasticity for speech learning during the first decade of life comes from the fact that, in cases of gross destruction of the cerebral speech areas, return of normal speech occurs much more rapidly and more completely than at a later age." Most neurologists and psychiatrists seem to be in general agreement with this conviction (*11*).

In addition to the development of linguistic skills, which are, of course, a vital, practical need in our modern world, there is another, subtler outcome of language study that is perhaps even more important. This is the change in attitude toward foreign peoples which can result from effective language teaching. Language is an integral element in the behavior system of a people, and at the same time it is the expression of the culture of that people. As the pupil progresses in his experience in the foreign tongue, he becomes increasingly aware that the new words and language structures he is using symbolize attitudes, aspirations, points of view quite different, frequently, from those symbolized by the corresponding words and structures in English. The learner imaginatively identifies himself with the people whose language he is using, and he takes on a whole new frame of reference without losing his own. In other words, he is breaking through toward something broader than monocultural orientation—he is developing an attitude of cultural relativism.

McGrath was aware of this potential outcome of an early start in language learning, and the experts

in child development, Arnold Gesell and Frances Ilg, have written pointedly (*10*): "The eight-year-old shows a new capacity to grasp total wholes. He thrusts outward, ranging widely in new breadths of interest. He makes a more rational approach to foreign lands and peoples, and often shows surprisingly insightful empathy for social life in other cultures." It may well be that this language movement in the elementary schools is the key to one of the major concerns of modern education—the successful teaching of international understanding.

Retooling in High School and College

Of course, there is no likelihood that all of our language teaching is going to gravitate to the elementary schools. Although it seems true that the optimum age for beginning a second language is somewhere below grade 7, some students will still begin language study in high school and in college—and with good results when the teaching is effective. It should not be overlooked here that, in many high schools and especially in the colleges, there has recently been a considerable revision in the teaching and status of languages. Since 1952, 15 colleges have installed or reinstated a degree requirement in languages for bachelor of arts candidates, and several colleges have put in an entrance requirement; the between-the-wars trend has been reversed (*12*). In the same period, nearly 100 colleges and universities installed "language laboratories"—mechanical and electronic equipment designed to facilitate language learning by groups or by individuals—a result of the new emphasis on hearing and speaking the foreign language. But those fortunate children who can get a start in the grades will have the advantage of an optimum beginning and the prospect of much more time in which to master the language. Most high-school teachers look forward eagerly to the day when they will receive these students, to work with them in advanced courses. Those students who go on to college will be ready for really mature work in the foreign language. When our system of education provides such an effective sequence of language learning for large numbers of our youth, the nation will be approaching an era of responsible custodianship in world affairs.

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Origin and Use of the English Peat Fens

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THE floodplains of the rivers (*1*) that drain into the Wash, on the English east coast, merge in their lower portions and form a lowland known as the Fens (Fig. 1). This region is bounded on the interior by gentle hills and plains that are not formed of materials laid down in water. The main characteristics of the Fens are lowness, nearly uniform flatness, and imperfect natural drainage. This landscape is unique in Britain and strongly resembles parts of the Low Countries in its monotonous levelness, localized settlement, artificial drainage, and thorough cultivation (Figs. 2 and 3).

Formerly the Fens were marsh that was unproductive and sparsely populated, but extensive reclamation works carried out since the middle of the 17th century have converted them into fertile, arable land. Today the Fens represent the largest single tract of first-class arable land in the British Isles (*2*). In all, the English Fens cover about 1250 square miles, some 550 square miles consisting of peat and the rest made up of mineral deposits (Fig. 4). The peat deposits are mainly located in the interior sections of the Fens, forming a distinct subregion, and this article seeks to outline the formation of the peat and to examine some major aspects of its present utilization.

Peat

Peat may be defined in general terms as an accumulation of partly decomposed vegetal matter deposited under marsh conditions. In order for peat to form, there must be incomplete decomposition of the remains of growing vegetation. Peat soils therefore differ from mineral soils in that they are largely derived from organic matter and have formed in the absence of air, which was excluded by waterlogging at ground level (*3*).

Plant remains usually decompose completely, through the action of bacteria and, to a lesser extent, of certain types of fungi. The activity of these organisms is drastically curtailed if excessive ground water excludes air from the soil interstices (*4*). However, some plants flourish in soils that are so waterlogged that their debris decomposes slowly. Under such marsh conditions, an imbalance between the rates of plant growth and decay may result. The ground surface tends to accumulate vegetal matter, and this leads, in time, to the formation of peat deposits. The accumulated plant residues are not entirely immune to decay but are converted into true peat by the action of a minor group of microorganisms that can work in the absence of air and, therefore, in waterlogged, marshy ground (*5*).

Peat deposits have widely different chemical properties. Their acidity or alkalinity is of primary importance, for it affects their agricultural value. Whether the balance of accumulating plant residues is acid or alkaline depends largely on the base content of the ground water in which the peat is formed. However, a peat-producing situation is generally associated with acidic ground water, and the resulting peat may be highly acidic. More rarely, the presence of lime-containing rocks gives rise to water that is sufficiently alkaline to neutralize the organic acids of the forming peat, or even to render the peat alkaline (*6*).

Peat occurs extensively in Britain, particularly in the upland areas. Most of it is of the acidic type, which, since its reclamation is generally uneconomic, provides only low-grade grazing of little agricultural value. Neutral or alkaline peats occur in several districts and, with drainage, may provide highly fertile farm land. By far the largest tract of such peat is located in eastern England, forming part of the region known as the Fens.

Origin of the Fen Peat

The present remarkable flatness and lowness of the Fen region is the result of an accumulation, at about sea level, of flat-lying deposits within a shal-

low basin structure. The formation of the basin, which provides a receptacle for the Fen deposits, can be explained by the weak resistance to erosion offered by the thick beds of clays that outcropped in the locality. These clays were originally worn away by a large, ancient river, flowing through what is now eastern England and across the former plains, now the floor of the North Sea (*6, 7*).

During Pleistocene times the Fen area was, of course, subjected to glaciation and, since the withdrawal of the ice sheets, it has undergone complex changes in the relationship of land and sea level. The result of these changes was the inundation of large areas of dry land to create the North Sea, with the Fen basin forming a shallow bay on that sea. Marine erosion within the bay may have furthered basin development, but deposition ultimately exceeded erosion. Thus, the arm of the sea came to be largely filled in, with the exception of that remnant today known as the Wash (*8*).

Two principal types of material have accumulated in the bay—silt and vegetal remains. Silt was apparently the most plentiful; some was brought down by rivers but most of it was marine silt carried by currents through the mouth of the bay (*9*). The silt deposition continues to the present day. Northeastern England is suffering sea erosion, and the detritus is transported southward, some entering the Wash to form extensive mudbanks. The present shape and growth rate of Spurn Head, at the northern entrance to the Humber River, indicates the southerly movement of material in these waters.

Because silt deposition in the Fen basin occurred mainly at the sea margins, the accumulation of silty material was most vigorous toward the north and east of the basin and resulted in obstruction of the river mouths. The clogging with silt of the river outfalls tended to force back the water of the rivers and to create fresh-water marshes on the landward side of the silt beds. In time, peat accumulated in the marshes and came to form the present peat Fens (*10*).

The ground water that gathered in the Fen basin marshes represented the concentration of drainage from the surrounding chalk hills. This water possessed slightly alkaline properties and contained abundant mineral nutrients, promoting luxuriant plant growth and the accumulation of large amounts of peat. Had this supply of plant nutrients not been available, only a moss vegetation might have survived, and the thick Fen peat would not have come into being (*11*).

Fen peat is derived mainly from the sedges, reeds, and other water plants that flourished in the undrained Fens (*12*). When young and only slightly decomposed, such material may have a light color; with age it darkens. Mature peat is brownish-black and is easily crumbled, resembling straw farmyard manure that has thoroughly rotted. The Fen peat has no clear structure and it entirely lacks contained stones, though small shells may occasionally be present. Such dark colored, crumbly, organic soil is usually termed *Fen peat, black peat, black Fen,* or *muck soil* (*13*).

Fig. 1. Location of the English peat Fens.

Peat has accumulated in the Fen basin in prodigious quantities, with deposits as deep as 20 feet. But formation of new deposits was abruptly halted wherever effective artificial drainage was instituted. Now the entire Fen area has been drained by a long series of integrated reclamation schemes, and peat formation has become past history.

In any case, even without man's interference, peat formation does not continue indefinitely; the deposits eventually rise above the zone of permanent saturation, a different type of vegetation develops, and peat no longer forms. Moreover, there is abundant evidence that peat accumulation in the Fens was a discontinuous process in the centuries that preceded reclamation. Indications of past changes in natural drainage—and therefore in vegetation—are afforded by means of pollen analysis. More spectacular proof occurs in the

Fig. 2 (left). Typical scene in the peat Fens. Note the open, level land and the drainage ditch. A crop of onions is being harvested at the right. Fig. 3 (right). Artificial drainage is very complicated on the peat Fens, as is indicated here by the drainage channels on two levels and at right angles to one another. The watercourse in the foreground passes under the higher channel, which is located where the figure stands beside a footbridge. Excess water in the lower drain must be removed by pumping, for the channel is several feet below mean sea level.

great buried forests of the peat Fens. These remains are in the form of tree trunks and limbs of all sizes, some more than 100 feet long, which lie at various depths in the peat (Fig. 5).

It is believed that the forests in the Fens predate the beginning of historic times (*8*), yet the buried trees, which lie in wet peat, have not decayed. In general, they are remarkably well preserved, for the same agencies that permitted peat to accumulate also operated to retard wood decomposition (*14*). The buried trees—"bog oaks," in local parlance—include not only oaks but also yew, fir, alder, willow, and other species (*15*).

The presence of these bog oaks suggests that the building up of peat in the Fens was a spasmodic process. In many places these trees are found at depths several feet below present mean sea level. This indicates a land subsidence relative to the sea, for the trees must, of course, have grown above the level of high tides and on land that was too well drained for peat development. Thus, these remains presumably indicate a period of relative dryness in the Fen peat marshes. Not infrequently, tree remains are complexly interlayered with both silt and peat beds. This suggests deposition under changing conditions of sea invasion, running fresh water, or marsh.

Topography

The outstanding feature of the Fenland topography is a general extreme flatness and lowness, with altitudes that average only a few feet above mean sea level, or even below. The explanation for this excessively subdued relief is found in the origin of the superficial deposits. Since these are very largely of peat and silt that were laid down in shallow water at levels not very different from that of the present sea, the flatness and lowness of the region are readily understandable. The collecting basin for the Fen deposits, which was composed of soft, weak clays, lacked any sharp relief, and most minor surface features of the basin floor were soon masked by the Fen peat or silt.

Apart from a few scattered patches of Fen basin clay and other material rising higher than 100 feet, known locally as Fen islands, elevations greater than a few feet above mean sea level are not to be found in any part of the Fen region. The peat Fens are generally the lowest portion of the Fens; elevations average about sea level and quite commonly are below this level. The silt Fens are slightly higher, with an average elevation about 10 feet above mean sea level. Before drainage, this situation was the reverse, with the peat standing higher than the silt (*16*). But drainage lowered the peat surface more than it lowered the silt. Today, the lowest elevations in the Fens are found away from the sea, on the peat lands.

One might suppose from the origin of the Fenland deposits that even a minor surface relief would be lacking. However, deposition of silt and peat was irregular, both in depth and in horizontal extent. Differential shrinkage resulted from the variable composition of the deposits, and there has been a variation in the effectiveness of drainage. These factors have contributed to the formation of considerable micro-relief. Examples are the localized

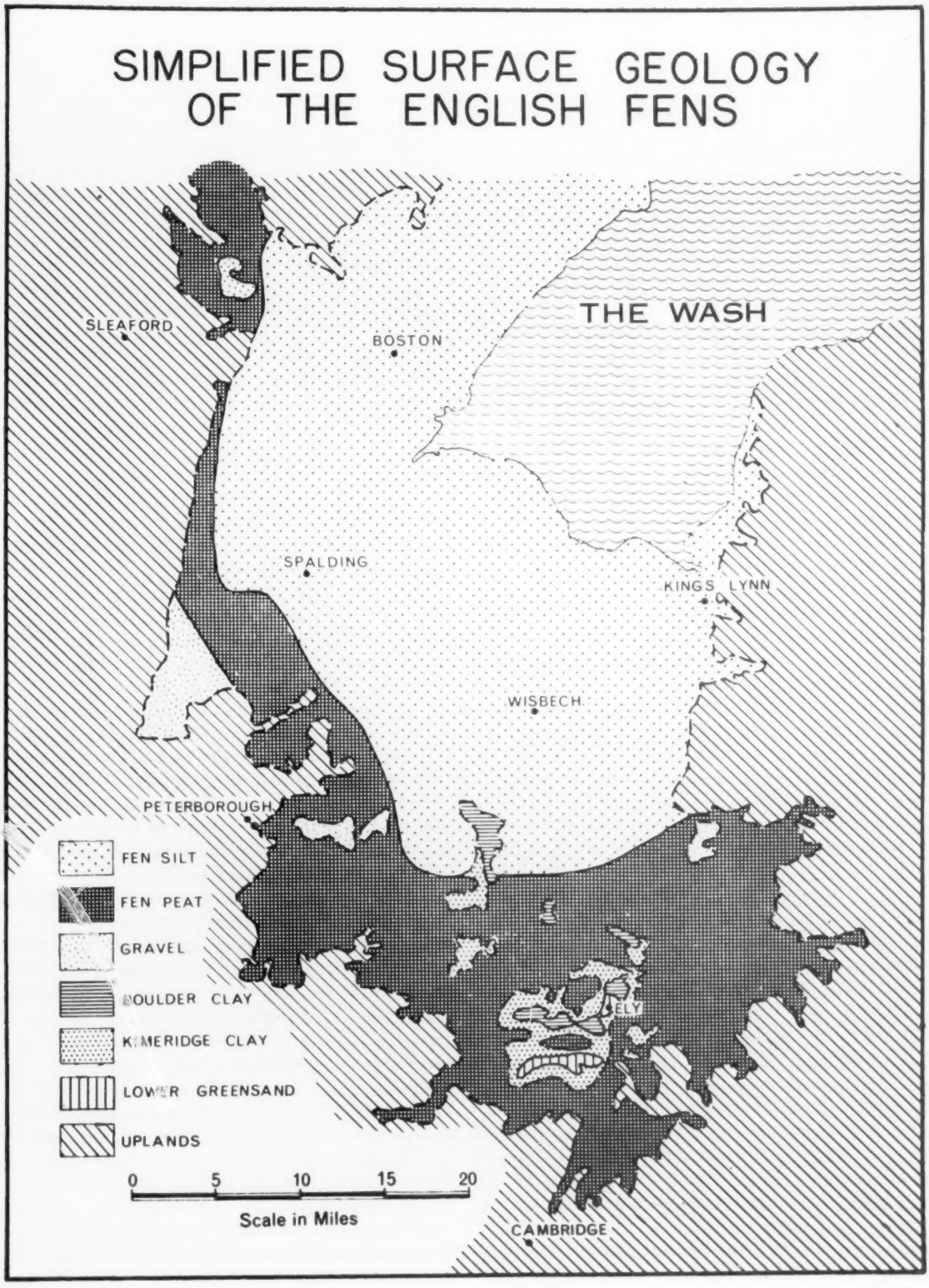

Fig. 4. Surface geology of the English Fens (*26*).

Fig. 5. The footbridge across this drainage ditch is a bog oak, which was left in position when the ditch was dug.

silt deposits that were laid down in ancient pools and streams in predominantly peat areas. Since drainage, the silt has lost less bulk than has the surrounding peat. Local surface features composed of silt are thus apt to be embossed in a peat area. The silt accumulations that mark the former courses of streams through peat districts nowadays stand up, in relief, as low ridges several feet higher than the surrounding land. Such features, termed *roddons,* may be quite prominent in the otherwise featureless peat areas. Beds or ridges of gravel that are glacial or postglacial in origin may form minor surface features, most commonly around the margins of the Fens. Most of the minor variations in surface relief are obvious only during floods, but different fields and portions of fields have "highs" and "lows," which are often critical to cultivation and settlement.

Man and the Peat Fens

Man has been an important geomorphologic agent in the Fens: for centuries, reclaimers have been embanking all types of watercourses, building up roads, and even elevating construction sites (Fig. 6). In all, vast quantities of soil and clay have been redistributed in the effort to adapt the Fen environment to man's needs. Not infrequently, such fill has been transported considerable distances. Many of the most prominent features on the Fen landscape do not occur naturally. Indeed, it is generally true that, with the exception of the Fen islands, the highest elevations throughout the Fenland are on the crests of the artificial embankments that flank most major watercourses and protect the coast line.

In return for man's great labors of reclamation in the Fens, a large area of fertile peat and silt soils has become available to the farmer. As stated previously, these reclaimed peat deposits occur principally in the interior sections of the Fen region. Roughly speaking, they lie in a broad sweep through the western Fens, with the largest expanse in the south. The landward boundary of the peat is the basin margin, which rises in the hills that more or less enclose the Fens. The seaward margin of the peat is largely formed by the silt deposits that make up the eastern and northern Fens. Scattered throughout the peat are numerous islands of clay or gravel, and gravel is found extensively on the landward border of the peat. Strips of alluvium border modern and extinct waterways in all parts of the peat Fens.

The boundary of the peat districts is far less precise than the geologic map implies. In fact, the peat almost always merges erratically with the bordering soil type. Rarely is there a clear-cut division between the Fen peat and the adjacent soil type, for each field, or even portions of each field, has soil distinctions that are associated with physical and historical circumstances as well as with the manner of past cultivation. Around the peat there is generally a wide and inconsistent zone of transition in which diverse organic and mineral soils occur. Such mixed transition soils are so extensive that they are recognized as a special group, locally known as "skirt soils."

The dark colored, crumbly peat is strikingly different in appearance from other British soils. Equally remarkable are the high crop yields and desirable agricultural qualities of the Fen peat. Thanks to the alkaline ground water in which it formed, Fen peat almost never requires lime. Nitrogen is abundant, but phosphate and potash are lacking. Commonly, there are deficiencies of certain elements that are needed in minute quantities by plants (*17*). Fen peat, like other peats, can hold very great quantities of moisture. This ability, coupled with the high water table of the Fen region, affords almost complete immunity from summer drouth, even though eastern England is one of the driest parts of the British Isles. Not only does the Fen peat hold much more water than do mineral soils but it also drains more freely than do most nonorganic soils. Indeed, the free-draining qualities of peat are such that cultivations can be carried out very soon after heavy rain, where the underdrainage is good.

The modern land use of the peat Fens is almost entirely agricultural. Mineral production is negligible, except for some sand, gravel, and clay. The high fertility of the peat Fens, as in the silt Fens, evokes an intensive, arable system of farming, with

Fig. 6. The water level of the river at upper right is slightly higher than the surface level of the peat land through which it flows. The embankments necessary to confine the river to its channel are characteristic of streams in the peat Fens. Note that the embankments are set back from the river to allow for the safe dispersal of some flood water. The farm and road are near the crest of the embankment, to escape flood dangers.

about 80 percent of the area under the plow (*18*). About 80 percent of this acreage, in turn, is in small grains, potatoes, truck crops, and sugar beets. Grass occupies a relatively minor position, and there are considerably fewer sheep and cattle per square mile of farm land than is generally the case in Britain. In contrast, interest in hog raising is greater than elsewhere, doubtless because of the small space requirements for hogs, their ability to thrive with little or no pasture, and their usefulness in converting crop residues into valuable manure. It is interesting to note that work horses are proportionately more numerous in the peat Fens than in most parts of Britain. This apparent anachronism in the otherwise progressive farming system of the Fens can probably be traced to the soft, damp, peat soils, which at times are impassable to most tractors but not to horses.

Extreme lightness has been mentioned as one of the most pronounced attributes of Fen peat. Such peat never clings to implements or footwear in the manner of most mineral soils, particularly those containing much clay. Lack of adhesive, and cohesive, properties renders Fen peat markedly susceptible to wind erosion, particularly when it is dry, for peat that is thoroughly dried out is slow to take up moisture again.

Wind erosion is usually considered unimportant in the British context. However, a "blow" on the peat Fens may stir up tremendous amounts of fine peat in a dramatic dust storm that reduces visibility to a few yards. Unbelievable quantities of topsoil may be lost in this way, and deep drainage ditches may be seen brimful of light peat after a severe blow. Such disastrous blows may occur more than once in a single year, and the crop in the affected area may have to be resown each time. Spring is the season of the most severe blows.

It seems clear that wind erosion in the Fens has been worsened by the increased planting of sugar beets and other root crops since World War I. The soil is harrowed and rolled in preparing seedbeds for these crops, and a moderately strong wind can perform erosion in March or April, when there is still little cover provided by crops.

Although loss of Fen peat from wind erosion has been accelerated in recent years, Fen peat has been shrinking ever since the region was extensively drained in the 17th century. Reclamation not only halted the formation of new deposits but also prepared the way for destruction of the accumulated stores. For one thing, there was considerable loss of bulk in the peat through reduction of contained moisture. This caused a distinct lowering of surface levels in the peat lands in the years that immediately succeeded effective drainage (*19*).

As a matter of fact, the fall in surface levels continued long after the land had become well drained and persisted to the present at a rate variously estimated from a fraction of an inch to more than an inch per year. This continuing wastage of the drained peat is brought about through decomposition promoted by microorganisms whose presence had previously been precluded by waterlogging. The aeration and cultivation made possible by improved drainage further stimulated bacterial peat decomposition.

The resulting loss of peat has been tremendous. Before draining began, in the 17th century, the peat lands, it is estimated, stood 5 to 7 feet higher than the silt areas; now the peat is about 10 feet lower (*6*). There are numerous illustrations of this

Fig. 7. This house, about 100 years old, was built in peat, but its foundations are on underlying clay. The peat level has subsequently been lowered about 7 feet by wastage. This has left the house entrances above ground level; the present first floor was formerly the basement.

great drop in peat levels. Old buildings on peat lands commonly have their foundations exposed and are usually badly tilted or cracked from shrinkage of the peat on which they are located (Figs. 7 and 8). The shrinkage disturbs roads and may derange tile drains, rendering them ineffective. In Holme Fen, near Peterborough, the top of a metal post that was driven 30 feet through the overlying peat into the underlying clay was level with the peat surface in 1848. Today, the post protrudes about 14 feet, and another inch appears every 2 or 3 years (*20*).

Peat shrinkage has not been uniform throughout the peat lands of the Fens. Among the more important factors that influence the rate of peat shrinkage are the duration and effectiveness of drainage and the duration and methods of cultivation. Where the mineral fraction of the peat soils has been high, wastage has of course been proportionately less. Thus, in proximity to rivers, where the soil is largely nonorganic and is permanently moist, shrinkage has been much less than in the areas of pure, open peat. Consequently, land adjacent to rivers, as well as the rivers themselves, has come to stand higher than the peat land through which the rivers flow. It has only been possible to confine rivers to their channels by building high embankments along their sides. This decline in peat levels has meant that the original gravity drainage on most of the peat Fens has had to be replaced by pumping (*21*).

In addition to deflation and decomposition, a source of peat loss has been its combustibility when dry. In times past, the lower layers of compacted peat were dug, cut into blocks, and dried for use as fuel. Extensive diggings have been worked during the centuries; this has resulted in substantial local lowering of peat levels, especially in the deep peat districts near villages. Many inhabitants of the Fens still remember when peat was the common fuel of poor people and can identify the particular lowness in an area with past peat diggings (*22*).

Thoroughly dry peat will burn in the ground, and fires, once started, will burn and smoulder for as long as 6 months. When well established, they are difficult to extinguish. Great quantities of surface peat have been destroyed in this way: it was once a regular practice among Fen agriculturalists to set fire to the upper peat as a means of increasing fertility and destroying weeds. This shortsighted practice has now been discontinued, though accidental peat fires frequently occur.

Wastage of peat, from one cause or another, has gone so far that pure peat has disappeared in many places and has been replaced by the variable, but basically mineral, skirt soils. Skirt soils are especially well developed on the Fen margins, where the peat was shallow and has receded through wastage. Even within living memory, areas of peat on the Fen margins have completely vanished, and peat farmers have become clay farmers.

The continuance of peat shrinkage will, in time, result in the complete elimination of all peat deposits. This prospect lies in the near future in the thin peat areas. The threat that the fertile peat will vanish and leave soils of low agricultural value is serious enough in itself, but, in addition, the declining land levels involved in the process will be attended by a worsening of the already serious drainage problems of the peat Fens.

Peat Conservation

Only a reversion to waterlogged conditions can stop the wastage of Fen peat. Some wastage is inevitable if the peat lands are to be farmed, but measures can be taken to reduce the present high rate. Claying, or the mixing of clay with surface peat, is a time-proven method of checking peat losses from the action of bacteria and wind as well as of enhancing soil fertility (*23*). Raising the water table in many places could minimize peat destruction by slowing bacterial activity and, to a lesser extent, checking wind erosion. There is evidence to suggest that the very efficient modern pumps available to the peat Fen reclaimers have resulted in overdrainage (*24*). More water in the drains, at safe levels, could well be valuable from the point of view of peat conservation.

Shelter belts of trees, of proved efficacy in checking wind erosion, might profitably be used more widely in the peat Fens. The land is too expensive for extensive reforestation, but narrow shelter belts would not interfere with present agricultural use of the land. On the contrary, they would impede the winds that sweep unobstructed across the nearly treeless and hedgeless Fens and would reduce wind erosion and the recurrent flattening of grain in summer. Windbreaks would also provide badly needed shelter and shade for livestock in addition to relieving the monotony of the bleak landscape.

An expansion of grass farming in the peat Fens could serve to slow down peat wastage. Wind erosion does not occur on peat that is in grass, and such land is not subject to flood damage, always a hazard in the Fens. Under a grass cover, bacterial destruction of peat is markedly reduced, beneficial effects on soil fertility are induced, and nematodes and other pests are checked (*25*).

Summary

The peat districts of the English Fens comprise a distinct region, unique in several important respects. First, its physical form is markedly different from most of lowland Britain—low, dead flat, organic soils, which, without artificial drainage, would be submerged beneath several feet of water. Second, the region constitutes nearly one-half of Britain's major tract of first-class arable land.

However, man's winning of the rich Fen peat has been succeeded by land-use problems that were not anticipated by the original reclaimers. Principally, peat formation under the former marsh conditions has been replaced by peat destruction under reclamation. The decline in peat levels, the result, mainly, of bacterial destruction and of wind erosion, aggravates the already severe drainage problems and points to the loss of the region's only resource—its rich soils. Nevertheless, peat conservation is possible: drainage modification, claying, extension of grassland, and wind-erosion preventives are some of the measures that may prolong the productive life of the fertile Fen peat.

Fig. 8. One cottage leans away from its neighbor as a result of peat shrinkage.

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21. The original reclamation schemes in the peat Fens were based entirely on gravity drainage flow. However, declining peat levels made necessary the introduction of pumping into some areas that could not be cleared of water by gravity. Windmills were first extensively used and, in the 19th century, were largely replaced by steam pumps. Nearly all the modern pumps are diesel-powered.
22. Peat is no longer excavated for fuel; the last diggings closed during the years between World Wars I and II.
23. Clay usually occurs beneath the Fen peat. To excavate it and mix it with the surface peat is a simple, though laborious, process. Since early in the 19th century, claying had been common practice on the peat Fens, but during the 20th century, it fell into disuse because of the high labor cost involved. In 1953 a government subsidy was offered to encourage claying, and with modern mechanical methods it is again becoming widespread.
24. Interview with engineers at hydraulic laboratory of the Great Ouse River Board, Cambridge.
25. K. Thompson, *Northwestern University Studies in Geography 2* (1957).
26. Based on Geological Survey sheets and on map from *The Fenland Past and Present* (*15*).

Summer Visitor

The photographic portrait of a locust (genus *Schistocera*) shown on this month's cover was made by Charles Walcott, a graduate student in zoology at Cornell University. The picture was taken at the Cape Romain Wildlife Refuge on Bull's Island, South Carolina, where locusts are quite common and can usually be seen sunning themselves on the fronds of the palmetto trees. *Schistocera* is one of the bird locusts of the family Acridiidae, so called because of the size of some of its members. This is an economically important group, especially south of the Mexican border, where one of its larger members, *S. americana,* causes a large amount of destruction on occasion.

American Foreign Aid: a Reappraisal

The National Academy of Economics and Political Science, Section K of the AAAS, and the National Social Science Honor Society Pi Gamma Mu held a joint symposium on American foreign aid at the Brookings Institution in Washington, D.C., 16 and 17 October 1956. The following three articles, by H. vanBuren Cleveland, Ragnar Nurkse, and Max F. Millikan, are based on papers that were presented at the symposium. The articles were edited by Donald P. Ray, executive secretary, National Academy of Economics and Political Science, and secretary, Section K of the AAAS.

Purposes of International Aid Programs

H. vanBUREN CLEVELAND

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THERE are three principal reasons for American economic aid to underdeveloped countries. Together, they largely encompass the entire field of foreign aid debate. One of these reasons is humanitarian. It insists that the main purpose of economic aid is to express concern for the welfare of peoples less fortunate economically. Aid, therefore, should be given to all countries (or at least all noncommunist countries) on a nondiscriminatory basis. Aid should be nonpolitical, administered without political obligations, and distributed according to objective economic criteria of need and "absorptive capacity."

At the opposite extreme is the definitive military approach, which sees economic aid simply as the handmaiden of military policy. It insists on a clear-cut military *quid pro quo* for economic aid. It would give economic aid, therefore, only to underdeveloped countries which we need in the defensive alliance system and which are willing to cooperate.

At the third corner of the triangle is that which might be called the political-economic case for foreign aid. The reasoning is that economic aid to underdeveloped countries will help build stronger noncommunist nations in Asia, the Middle East, and Latin America—nations better able to resist the advance of communism; that it will increase our foreign trading opportunities and those of industrial allies; and that it will help the underdeveloped countries along the road to democracy.

These three contrasting approaches are examined critically herein to determine what each has to contribute to the foreign aid debate and whether singly or in combination they might comprise a convincing rationale of foreign aid.

Humanitarianism

Like diplomacy and military force, economic aid is a tool of foreign policy. Its purpose is to protect and advance the national interest of the United States. If this is true, foreign aid cannot be an essentially humanitarian enterprise. There are people in all countries who are willing to make real sacrifices to aid less fortunate peoples, without consideration of national advantage. But the effective majority of every nation is made up of those whose highest common aim is their own country's welfare and security. That aim sets the limits within which a government can act.

Some nations are more fortunately situated than others in that their welfare and security are largely compatible with the welfare and security of their neighbors. Some are more willing than others to seek security, wealth, and power in cooperation with other nations rather than at their expense. We may properly demand of a nation that it go as far in this direction as circumstances permit. But that is the highest standard of international morality that can reasonably be asked. In practice, nations generally fall far short of the goal.

Are humanitarian motives, then, wholly irrelevant to American foreign policy? By no means is this contention true. Foreign policy seeks to further national interests by establishing mutually advantageous relations with other governments and peoples. The more dependable such relations can be made, the more valuable they will be. But a relationship based solely on cool calculations of advantage, without any underlying sympathy and trust, is not very dependable, even when there are

excellent objective reasons for continued cooperation. The relation is undependable because it will sooner or later be corrupted by resentments about a lack of mutuality. And this is as true of relations between governments as it is of relations between individuals.

This observation can be illustrated both positively and negatively from experience with foreign aid. The relation between the giver and receiver of aid, even when the aid is based on clearly perceived mutual interests, is a difficult one. The receiver of aid comes all too often to resent his subordinate status and to suspect the giver of nefarious purposes. The giver, for his part, is likely soon to conclude that the deal is one-sided to his disadvantage, and he is tempted to use his economic bargaining power to achieve results outside the original bargain.

Yet this difficulty has sometimes been overcome when there has been something more to the motives in giving aid than a concern with security. Winston Churchill once called the Marshall Plan "the most unsordid act of history." His generous words reveal his feeling that many Americans supported the Marshall Plan not merely because it was good for policy but also because they were genuinely concerned for the people of Britain and Europe and felt their own fate to be inextricably linked with the fate of European civilization. The Marshall Plan was not a humanitarian enterprise; aid to Europe was vitally important to American security in the years 1947–50. But the moral overtones of the plan help to account for the creative vigor with which it was administered, and for the answering vigor of the European response. Had this aid been motivated solely by considerations of national advantage, it would not have been as successful as it was in building a sense of community within the Western world.

Building community between Asia and the West is, of course, vastly more difficult than building it within the Western world. The generous motives of some Americans will not be sufficient in themselves to bridge the deep political and spiritual gulf which now separates the agrarian East from the industrial West. That gulf will be bridged (if it is ever bridged) by slow, unpredictable processes of history. Nevertheless, generous motives in dealings with Asia and Latin America, and the response of trust they may call forth, are an essential part of this bridging process.

The same point may be made in another way. Whenever relations with another country lack the dimension of mutual concern and trust, basic common interests are frequently obscured by passing irritations. Annoyance with Nehru's ambiguous foreign policy, for example, tempts us to lose sight of our major interest in the success of India's experiment with democratically controlled economic development. The genuine concern of many Americans for the welfare of the Indian people is a useful, perhaps an essential, antidote for the desire to punish Nehru for his double standard of international morality.

Humanitarian feelings, then, play a desirable and even a necessary part in *motivating* foreign aid, but they do not and should not determine the *content* of aid policy. Accordingly, the decision of what countries are to receive aid and how much cannot properly be made on the strictly humanitarian grounds of "need" and "absorptive capacity."

Economic Interests

If the content of foreign aid policy (as distinguished from its motivation) is defined by national interests, what interests does aid serve and how does it serve them? Should economic aid be continued, for example, mainly to further military interests, by giving most of it to countries threatened by communist attack which are willing to join in an alliance? Economic aid is certainly a useful instrument of military policy. The "pay off" in terms of security is far more certain when aid is used in this way than it is when aid is used in any other way. And the military value of economic aid has been amply demonstrated in Greece, Turkey, South Korea, Formosa, Indochina, Japan, and the Philippines, not to mention Western Europe. But to confine economic aid to this purpose is to take a much too narrow view of our interests in the underdeveloped world and of the way in which aid can further these interests.

The nonmilitary case for aiding underdeveloped countries is sometimes argued on the basis of our strictly economic interest in an expanding international economy. The argument is that our needs for imported raw materials from underdeveloped countries are expanding rapidly and that, in the past, economic growth has normally been accompanied by a rapid expansion of trade between industrial and underdeveloped countries. Expanding markets and investment opportunities in Latin America and Asia will assist in maintaining employment and a high rate of economic growth here. And these things are even more true of the economies of industrial allies in Europe and of Japan than of our own, more self-sufficient economy.

This reasoning, however, is not overly persuasive. The pattern of national economic development in Asia, the Middle East, and even in Latin

America, is increasingly autarkic. Forced industrialization for nationalistic ends is more often than not the dominant theme of development planning. Underdeveloped countries today consider specialization on food and raw materials as "economic colonialism," and "economic independence" (that is, industrial self-sufficiency) is a central objective of economic development. In this context, accelerated development cannot be expected to make the contribution to the economic growth of the United States or allied countries which is often hopefully predicted. Development will doubtless mean some expansion of trade between the industrial and the underdeveloped countries. But that expansion will not be nearly as rapid, in relation to production, as was formerly the case.

Political-Economic Interests

For this reason, the better nonmilitary case for aiding underdeveloped countries stresses the relationship between economic development and political interests, rather than that of economic interests alone. The position states that economic progress in underdeveloped countries will be accompanied by political progress—that it will help build strengthened national states able to resist communist subversion and willing to maintain a pro-Western or (at least) a neutral position in the cold war. For the longer run, the hope is expressed that economic progress in Asia and Latin America will lay the basis for constitutional forms of government.

The belief that economic development will strengthen noncommunist governments in the underdeveloped world is sometimes based on the simple proposition that rising living levels usually bring political improvement. A better argument is that economic development will help to mitigate certain characteristic causes of unrest and disaffection in underdeveloped countries. In several of the most strategically located countries of southern Asia, for example, there is serious and growing rural overpopulation. The pressure on the land is so great that rural living levels have tended to decline. In southern and southeastern Asia as a whole, the per capita output of food grains has not yet returned to the pre-World War II level and is apparently well below the level of half a century ago. The resulting agrarian unrest is naturally a priority target for the communists. Obviously, there is no easy solution to so difficult a problem. But progress in that direction depends on greatly accelerated economic growth—specifically, a speeding-up of the growth of food production and a rapid expansion of urban employment.

Middle Classes

Another critical economic problem, and one which is common to most underdeveloped countries, is the lack of sufficient economic opportunity for the urban middle classes. Many of these people are dangerously disaffected because their economic expectations have expanded more rapidly than their opportunities. One of the first products of economic development seems to be a rising demand on the part of the urban middle classes for economic satisfactions and opportunities—a demand which often seems to grow more rapidly than the means of satisfying it. The result is serious frustration and resentment. Political historians like to point out that revolutionary classes are seldom the most oppressed groups but rather those whose expectations of improvement have been aroused, only to be frustrated by the "old regime." This seems to be as true of the urban middle classes of the new Asia as of the French bourgeoisie of 1789, or of the Russian soldiers and factory workers of 1917.

Accelerated development provides a way of coping with this problem. Accelerated growth of industry, commerce, and government services will provide many more jobs and economic opportunities for the middle classes. Programs of national economic development can help channel their ambitions and energies into constructive action and away from communism and adventuristic nationalism.

The uncertain relationship between the end sought (greater political stability and less anti-Westernism) and the means used (aid to economic development) should not be concealed (*1*). One difficulty has already been suggested: the process of economic modernization may itself generate expectations of improvement more rapidly than they can be satisfied. No doubt some economic dissatisfaction is necessary to achieve any economic progress; without it economic growth would be a sporadic or accidental phenomenon rather than a self-sustaining process. But if the margin between economic expectations and achievements becomes too wide—either because expectations are too unrealistic or achievements too small—there may be a political explosion.

There are unfortunately good economic reasons why economic development in some countries may fall short of current expectations. Most underdeveloped countries today start from a considerably lower economic level than did Western Europe at the time of the Industrial Revolution: they have neither the accumulated wealth, nor the per capita productivity, nor so favorable a ratio of population to natural resources. And the problem of accumu-

lating capital is more difficult than it was in Western Europe or North America at a comparable stage of development. In the West, industrialization was the unplanned consequence of decisions of private entrepreneurs. The accumulation of capital could proceed, therefore, without having to compete in the political arena with interests concerned with raising living levels and redistributing income. This position is not the case in most underdeveloped countries today.

The underdeveloped countries do have certain economic advantages over Europe as it was before the Industrial Revolution. They are able to borrow and use a ready-made technology. They have ways of accelerating capital formation and industrial growth which were not invented in the 19th century. In consequence, the rate of growth of production achieved in a number of these countries in recent years has been a good deal higher than it was in 19th-century Europe. But that which advances political objectives is less the absolute growth of output than the growth of per capita consumption. And here the unprecedentedly rapid growth of population makes progress very difficult.

Considerations such as these have led some observers to the pessimistic conclusion that to aid economic development is to export revolutions—revolutions which are more likely to benefit the Soviet Union than the United States. This conclusion is certainly too sweeping and too negative in nature. It is apparent, nevertheless, that the difficulties of modernizing the lesser-developed societies do present great opportunities for the communists.

To many leaders of the new Asia, rapid industrialization has become the principal aim of development because they see it as the most direct means to national independence and international prestige. To these leaders, the desire to increase living levels is secondary to the primary task of building industry, especially heavy industry. These leaders see communism mainly as a method of proven effectiveness for developing a backward country—a method which penetrates the consumption-investment dilemma by giving investment an overriding priority and crushing opposition by totalitarian means. A communist or authoritarian socialist model of economic development is more attractive to them than the Western model, which, being more responsive to consumers' wants, yields a slower growth of heavy industry. When a nation makes industrialization an end in itself, rather than a means to higher living levels, the step to some form of authoritarian socialism or communism is not a long one.

In this connection, the purpose of Soviet economic aid to Asia and the Middle East is worth pondering. The U.S.S.R. apparently has given no authoritative explanation, beyond that suggested in a 1949 *Bolshevik* article by Stalin, of their economic policy toward noncommunist Asia. Doubtless, their immediate objective is to increase the economic and diplomatic dependence of Asia on the Soviet Union and to reduce the West's trading opportunities there. But it is possible also that they wish to encourage rapid industrialization in Asia because they think it will pave the road to communist regimes.

Marxist-Leninist theory is attractive to middle-class elements in the underdeveloped countries because it offers an emotionally satisfying explanation of their nations' poverty and of their own frustrations. According to Marxist dogma, all differences in wealth and poverty are due to "capitalist exploitation." If the underdeveloped countries are poor and backward, therefore, it is because of exploitation by the capitalist powers. If there is backwardness and a lack of economic opportunity, it is because domestic feudal elements are in league with domestic capitalists and foreign imperialists.

This ideological concoction may ignore the real social and economic causes of poverty in lesser-developed nations. But it has just enough relevance to their historical experience and present problems to be effective in focusing the resentments of Asian and Arab nationalists against the West. In this way, leaders in many of these countries, including those who are neither communists nor socialists, are coming to see relations between their countries and the industrial West as a kind of international class struggle with overtones of racial conflict.

Objectives

The political results of economic aid and economic development in Asia and Latin America would seem to be quite uncertain. Proponents of aid, nevertheless, in their anxiety to convince an indifferent public, have often felt it necessary to claim a clear-cut correlation between aid and the achievement of American objectives in underdeveloped countries. In so doing, they oversell their product and help to build unrealistic expectations. The inevitable disillusionment could lead to resentments here and abroad which would bring aid programs to a halt and undo their favorable political results.

The alternative to overselling foreign aid is to make the case more modestly, more pessimistically perhaps, but above all, more courageously. The simple truth is that, despite uncertain results, the United States has no alternative to a vigorous aid policy. What happens in Asia, Latin America, and

the Middle East is of vital concern to us. The revolutionary social transformation now going on in these vast areas will shape the fate of most of the earth's population; it may well determine our own fate and that of civilization. The question is not whether but how to participate in it, in the hope of influencing the outcome in directions compatible with our basic interests.

Diplomacy, however, is not very effective in dealing with sovereignties so suspicious and resentful of the West. And to impose our will unilaterally by political or military means, except as final resort in matters of direct threat to vital national interests, is highly questionable—not because of the difficulty of military operations but rather because of political repercussions in the neutralist world. Economic and technical aid, therefore, is the principal means of policy now available. To influence the course of events, cooperation must be obtained on whatever basis of common interest might exist. And today the most promising basis is a common concern with economic development. The natural role in this cooperation is to provide capital, technology, and friendly counsel on problems of development, planning, and administration.

If this is the underlying rationale of aiding underdeveloped countries, it is neither necessary nor candid to argue that the probability of success is high. Supporters of aid need not feel bound to demonstrate that aid programs are a sure cure for communism; that aid is certain to bring rising living levels; or that the rising living levels are reasonably sure to bring greater political stability and pro-Western political orientation. It should be sufficient to point out (i) that there is a real possibility that aid to economic development abroad will further American interests as outlined here; (ii) that there is no better alternative means of influencing the course of political development in the nations in question; and (iii) that there is no choice but to act because the stake in the political future of the underdeveloped world is much too high to permit indifference (*2*).

References and Notes

1. For discussion, see *Economic Development Abroad and the Role of American Foreign Investment* (Committee for Economic Development, Washington, D.C., 1956) and E. Staley, *The Future of Underdeveloped Countries* (Council on Foreign Relations, New York, 1954).
2. The opinions expressed here are mine and not necessarily those of the John Hancock Mutual Life Insurance Co.

Foreign Aid and the Theory of Economic Development

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THE concept of surplus farm labor has attracted increasing attention in underdeveloped countries. The simplest definition of it implies that some labor could be withdrawn from subsistence farming without reducing the volume of farm output. In technical terms, the marginal productivity of labor is believed to be zero. If this is true, it has some far-reaching implications. But is it true? Is it even conceivable? Some economists have serious doubts on this score. Certainly the idea of "disguised unemployment," as it is usually called, has sometimes been carelessly formulated and inadequately substantiated.

The subject must be viewed in relation to the general population problem. The crucial fact is that world population has doubled in the last 100 years. About two-thirds of the increase has taken place in the economically underdeveloped areas, chiefly in Asia, largely through a fall in death rates. This has been part of the uneven impact of Western civilization on the rest of the world. In the poorer countries, as a rule, the majority of the population works in agriculture to start with, for basic and obvious reasons. In such countries, rapid population growth naturally leads, and in some has already led, to excess population on the land.

Effect of Population Growth

Consider for a moment the effects of population growth in a community of peasant cultivators. Numbers are increasing while land, capital, and techniques remain unchanged. Alternative employment opportunities may be lacking because

of the rigid social structure, and may actually be decreasing because of the decline of traditional handicraft industries due to the competition of imported manufactures. With the growing pressure of people on the land, farms become smaller and smaller. What is more, farms are divided and subdivided into tiny strips and plots. The increasing fragmentation of the land absorbs labor-time in various ways—for example, simply by making it necessary for people to walk from their homesteads to the scattered plots and from one plot to another. It wastes not only labor but also scarce land because of the paths and boundary strips which can take up as much as one-fifth of the surface. In a number of countries, including India, fragmentation has not been a fixed cultural characteristic but has developed progressively in the last 50 or 100 years as a direct result and reflection of population pressure. It is clear that overpopulation has been the cause of the *increasing* subdivision of peasant holdings.

Fragmentation can be regarded as a make-work device for the growing masses of people. The labor surplus in subsistence farming is *concealed* in this way. The term *disguised unemployment* is for this reason not inappropriate, though it may be objectionable on other grounds. Some of the rural unemployment can be quite open—for example, seasonal idleness of peasant farmers or unemployment among landless laborers. Moreover, when fragmentation takes place in response to population pressure, the process is naturally subject to a lag so that at any given time there may be some backlog of labor not yet absorbed by increased subdivision of land.

To the extent that the labor surplus is absorbed —and concealed—through fragmentation, it cannot be withdrawn without bad effects on output unless the fragmentation is reversed and the holdings are consolidated. Over a limited range, the marginal productivity of labor might be zero without any such reorganization. It could be zero over a much wider range if the remaining factors of production were appropriately reorganized, which would require, for one thing, a consolidation of plots.

There are a number of empirical studies that tend to confirm this picture. The evidence can never be entirely satisfactory in a matter such as this in which some things, including the weather, would have to be held constant and others subjected to a reorganization which might necessitate a revolutionary change in rural life, bringing, inevitably, other changes with it. Nevertheless, the connection between overpopulation and fragmentation, which has been stressed, for example, in the writings of D. R. Gadgil in India and in the United Nations reports on land reform, goes a long way toward making the existence of surplus farm labor plausible.

Theoretical Considerations

So much for the factual side. On a theoretical view of the matter, it is clear that excess population can be so great in relation to land and capital that the marginal productivity of labor is reduced to zero. There are, however, two reasons why this idea may be difficult to accept. First, anyone trained in Western economics would have to ask: Who would employ these people if their product is zero? Or else one might ask: How can these marginal people live, and what do they eat, if they really produce nothing?

The answer to the first question is that in many countries the wage labor system, which we are apt to take for granted, hardly exists. The prevailing condition in subsistence farming is one of peasant family labor. The answer to the second question is that they live through sharing more or less equally in the total product of the farm, which includes the product of intramarginal labor and of any land and capital goods the peasants may own. The product from these factors goes into common use in which the members of the household participate. These institutional arrangements are foreign to the economics of business enterprise, and the conditions which they make possible may seem paradoxical.

If this sharing of food is considered a little further, the ultimate limit to the multiplication of people on the farms becomes starkly plain. If the average total product per person falls below the physical level of subsistence, the outcome is the Malthusian state of starvation which cuts down numbers or at least checks their further increase. At the point where this average product equals the physical subsistence level, the marginal product of labor may well be zero or even negative (*1*). Still, it need not be as low as zero. Conversely, if and when labor's marginal product is zero, the average product need not be as low as the physical subsistence level; it may be a little above that level.

In any case, excess population necessarily implies that the marginal product is less than the average. In this state of affairs, further population growth brings down the average level of consumption. Why? Because the additional labor contributes less than the average worker previously, and thus it pulls down the average product per capita. If the average product is as low as we know it to be, it does not seem far-fetched to suppose that in some cases the marginal product of labor may be

zero. Needless to say, the argument does not depend on its being exactly zero, although this is a convenient case on which to concentrate the analysis. The essential point is that the marginal workers live, in effect, on a subsidy if their own contribution to output is less than their intake of food and other necessities.

Capital

The question might still be asked: Why this obsession with the margin? Why not stress the obvious fact of a low general level of productivity? The answer is that the marginal approach is useful here because of the need to take away some labor from current production for work on capital construction.

The low general level of productivity has many causes, some of them cultural; but there is one in particular that concerns the economist, and that is the shortage of capital. It is easy to see that concealed unemployment carries with it a concealed saving potential as well. Surplus labor, which is not producing enough for its own support, is being subsidized by the rest of the peasant community. This subsidy could be turned into productive saving if the surplus people were set to work on capital projects while continuing to be supported by the peasants remaining on the land.

The difficulties of realizing this potential may be tremendous. That is an administrative or institutional problem. The analysis merely points to the possibility of a domestic source of capital in overcrowded peasant communities. Certain leakages are probably inevitable. United States farm surpluses could well be used to meet any food deficit that might arise. But at least a partial source of capital formation is present in the conditions described.

Concerning the general population problem, the advice usually given is: slow down the rate of increase. But a state of excess population has already been reached in some of the poorer countries as a result of the population explosion of the past 100 years; and this would exist even if there were no further increase. A demographic remedy here would require not merely checking the rate of increase but also actually *reducing* the number of people.

Another solution is possible. Population is excessive in relation to capital and natural resources. If population cannot be reduced, it is still possible to reduce its excessiveness by increasing the stock of the other factors of production. Even land can be created through river dams and irrigation. Yet, in general, nothing much can be done about the gifts of nature except that the amount of *useful* natural resources is never a fixed quantity but always a function of people's knowledge and know-how. But about capital something can be done. Excess labor can be put to work producing additional real capital. This is the only practicable policy of relieving the problem of excess population.

Some writers argue that, since the problem is agricultural overpopulation, the cure is to transfer labor from agriculture to industry. Even though industrialization is a normal consequence of development, this view is superficial. The effect of overpopulation is low productivity, for which capital formation, not industrialization as such, is the basic economic remedy. In what particular fields the capital is applied depends on many things, including foreign-trade opportunities and domestic income elasticities of demand. Often it is the category of public overhead facilities that claims the biggest share in a poor country's investment program. Often it is here that surplus farm labor can best be used: in building roads, railroads, schools, power plants, and irrigation works.

Not all the poorer countries suffer from the trouble of excess population. This picture applies best to a group of countries to be found in the general area from Southeast Europe to Southeast Asia—an area of special interest in the present-day world. There is nothing like it in the Western Hemisphere except in a few places.

Apart from this geographic limitation, the preceding sketch has all the usual limitations of any simplified outline. Yet it contains enough essential reality to make it significant to the problem of foreign aid and economic development.

Demonstration Effects

In considering the external environment of the poorer countries today, reference must be made to the so-called "demonstration effect." On the international plane, this concept implies that the propensity to consume in the poorer countries is excessively stimulated by the urge to imitate advanced consumption patterns, especially American ways of consumption. The theory is concerned with the choice between consumption and saving out of a given income. The demonstration of advanced living levels is believed to influence this choice in favor of consumer spending and to make saving harder in underdeveloped countries. If this is true, it constitutes a handicap for these nations today. Here, as in other economic affairs, no conclusive statistical proof is possible. It is a matter of common observation.

In some of the poorer countries, the behavior

of the local entrepreneurial classes especially is influenced by the demonstration effect, which leads these classes to spend their profits rather than to save. The Western system of business enterprise has always been marked by a high rate of business saving. W. Arthur Lewis in his recent book, *The Theory of Economic Growth* (2), puts the main emphasis on business profits as a source of capital accumulation in less-developed economies and even favors inflation as a way of increasing the share of business profits in the national income. Is this not an extension of conventional Western ideas to conditions where they are perhaps inapplicable? As an instrument of forced saving, inflation is supposed to work, and no doubt has often worked, by shifting the distribution of income from people with a low to people with a high propensity to save. But does it work in the poorer countries today? A shift to profits does not increase total saving where the profits go at once into luxury spending rather than business saving. In a country like India, this seems to be one reason the state is proposing to take a leading part in saving and investment activities.

Against this unfavorable effect of advanced consumption standards, some economists have stressed the favorable effect which these attractions can have by creating incentives to work harder and produce more. This is another demonstration effect: it concerns the choice between leisure and work. It is a useful reaction in some circumstances —for instance, when natives in Africa where labor is scarce are drawn into the money economy. But does it make the American worker work longer hours? He seems to prefer a shorter working week. And in the rest of the world the imitation of American living levels may partly take the form of increased demands for leisure. Demonstration effect No. 1 may block demonstration effect No. 2.

In addition, one can raise the fundamental question whether increased production through longer working hours constitutes progress at all. It can be argued that true economic progress means greater efficiency of labor, not a greater quantity of inefficient labor. It is desirable to have a higher output per man-hour, rather than more hours worked. To the extent that output per man-hour depends on capital, it seems at least possible that demonstration effect No. 1 makes progress harder in the underdeveloped countries.

There is a demonstration effect in a broader sense that is worth considering. Comparison of material welfare is meaningless when tastes are altogether different. Today tastes are becoming more uniform, the desired patterns of consumption more similar. Statistical indications point to a widening gap in real income between the richer and the poorer countries. Because of the increasing similarities of tastes and desires, this gap is acquiring a greater psychological significance. The economically underdeveloped nations now *feel* poorer than the others, and this is what matters.

Rich and Poor Countries

The current distinction between rich and poor countries reflects a state of affairs that hardly existed 100 years ago. At that time, the familiar distinction was between the *old* countries in Europe and the *new* countries in temperate latitudes overseas, not poor by contemporary standards but growing rapidly with the aid of migration and capital from Europe. And then there were the exotic countries in Asia and elsewhere. But these were countries to which Western economics did not apply. These were countries that felt indifferent or even antagonistic to Western material standards. Since then, these standards have conquered the world. All this may make the poorer countries more ready to change their traditional ways of life for the sake of economic development. But it can also lead to disturbances harmful to their progress.

Even if it can be recognized that the demonstration of advanced consumption standards may be a retarding or disturbing influence, it is necessary to take account of the demonstration effects on the side of productive technique and scientific knowledge, and these are, in general, favorable. The poorer countries are in a position to take over and make use of at least some of the technologic achievements already developed in the more advanced countries. This point can be related to a wider question. If the less-developed countries are to match the richer, must they go through the same successive stages of development? Probably not. Unlike the Western nations in the 19th century, they are not developing the industrial system, they are trying to adopt it. In doing so, they are faced with peculiar problems of large-scale transformation, but they can hope to skip some of the stages through which the countries before them had to pass. We need not blame them for seeking shortcuts, since these exist. The spread of technology is only one example.

In the field of international trade, the view that the poorer countries' terms of trade have shown a persistent tendency to deteriorate has gained some support from Charles P. Kindleberger's new book, *The Terms of Trade: a European Case Study* (3). Other recent studies have shown that world demand for the poorer countries' export products

has tended to rise much less than in proportion to the richer countries' incomes and production. It is chiefly among the richer countries that international trade has been expanding in the recent past. The richer countries themselves are efficient primary producers, especially of food. Their demand for exotic raw materials like crude rubber, silk, nitrates, jute, and vegetable oils has been, and will almost certainly continue to be, affected by the growth of the chemical industry in the 20th century. This is probably one explanation of Kindleberger's findings. Only for minerals is the prospect favorable.

Balanced Growth

It is clear, therefore, that the less-developed countries, even if they are only to keep pace with the richer, to say nothing about matching them, must expand production for their own domestic markets. Their domestic markets now are limited because of mass poverty resulting from low productivity. Private investment in any single industry considered by itself is discouraged by the smallness of the existing market. The solution seems to be a balanced pattern of investment in a number of different industries, including agriculture, so that people working with more capital and therefore more productively become each other's customers. This is the so-called doctrine of "balanced growth"; it aims to enlarge the size of the market and to fill the vacuum in the domestic economies of low-income areas. How it is to be done, through private enterprise or government planning, is again basically an administrative question depending on local circumstances. The doctrine of balanced growth does not prescribe any particular method. It offers a diagnosis and points to a goal. Nor is this doctrine concerned with the question of where the capital is to be found, for all the balanced investment which it envisages. It takes an increased supply of capital for granted. We must go on to ask where the capital is to come from.

Is it to come from outside? To some extent, perhaps. But can the poor countries count on receiving *private* foreign capital in anything like the same proportions as the new countries did in the 19th century? This is, of course, extremely doubtful. For one thing, the international trading position of the poor countries at the present time is hardly comparable with that of the new countries, which received most of the capital flow in the 19th century and in return supplied the great mass of food and fibers for which there was such a strong demand from the rising industrial nations. Quite apart from political difficulties, the commercial incentives for a large-scale movement of private capital to the low-income countries may be nonexistent. If this is so, any capital that is to come from outside would have to come, in part, through government channels.

Conclusion

Current political conditions of competitive coexistence may induce some competitive capital movements to the poorer countries, but everyone realizes that such movements are, in the nature of the case, unreliable. The long-term outlook for income transfers from rich to poor countries is not bright. We need not rule out the possibility of continuing such transfers as are now going on, chiefly under American auspices, but also in the form of international technical assistance programs. The arguments against them are often reminiscent of the objections levied against the growth of progressive taxation in the United States and other advanced countries in the last few decades. Actually, private investment in some of these countries, above all in the United States, has recently been forging ahead vigorously despite a highly progressive tax structure. The fear that international grants would destroy incentives and demoralize both the giving and receiving countries might likewise prove to be exaggerated. The analogy between internal and international income transfers is interesting, but it can be misleading. There is a very simple yet crucial difference between internal and international transfer payments: the poorer countries do not command any votes in the United States. As long as this is the case, such transfers are likely to remain a limited and precarious source of financing development.

The final conclusion is that countries should use their own resources to the utmost. This conclusion is a platitude, and leads back to our first point concerning the use of surplus farm labor, if and where it exists. Domestic effort is always the first prerequisite. Without it even the most lavish foreign aid could not achieve economic development.

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Future of American Foreign Aid

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THAT foreign aid has a future seems to be no longer in doubt. The amounts, characteristics, distribution, and administration of the program will depend, however, on the answer to a number of questions that have not yet been resolved in current debate.

There is growing consensus on a number of broadly stated propositions: (i) that the United States has an important interest in the economic growth of the underdeveloped areas; (ii) that the limited capacity of these areas to absorb additional capital productively sets a relatively low ceiling on the size of any economic aid program which is conducted in a businesslike manner; (iii) that economic aid should be provided without political obligations; (iv) that economic aid should be separated from military aid; and (v) that there should be a substantial measure of international administration in future aid programs (*1*).

Each of these broad propositions is more nearly valid than its negative, but there is danger in the heat of public controversy of oversimplifying alternatives. Each statement conceals a number of involved issues which need a great deal more thought and study before serious men can be sure that they can confidently outline the future of foreign aid. Some of these issues can be suggested in the hope of stimulating further deliberation concerning them.

Our Interests

Is it in the interest of the United States always to foster economic growth in every country regardless of the circumstances? It is usually asserted that our interest derives from the fact that in the underdeveloped countries some degree of economic growth is a necessary condition for political stability and the strengthening of democracy. If people's aspirations for improvement of their lot are frustrated, they are likely to turn to violence and to extremist movements like communism.

But if these countries achieve some growth, does this give any assurance that they will foreswear such movements in favor of democratic political forms? Although growth may be a necessary condition for political stability, is it always a sufficient condition? Has the rather extraordinary economic growth of the Soviet Union fostered democratic tendencies in that country? Should we support economic growth in China and the European satellites? Some students of the subject reply in the affirmative.

If, on the other hand, the answer is negative, is a line to be drawn only at countries which are already firmly communist? What about the case of Yugoslavia? Are there now or may there be in the future cases of countries in the Free World where the political process is developing in such a way that to support economic growth will weaken rather than strengthen the kind of political evolution of which we would approve? While it is hard to find actual cases of countries presently in the Free World of which this might be true, hypothetical cases can be imagined. How could they be recognized and what criteria could be attached to aid programs which would exclude them? If there are or may be such cases, are we really sure that we shall never want to apply "political obligations"?

Capacity for Absorption of Capital

With regard to the second proposition of a country's absorptive capacity for capital and the size of aid, can we be sure that the application of objective criteria of productivity will reduce all demands for economic aid to manageable levels? In general we can, because the capacity of the underdeveloped areas to absorb additional capital productively is rather severely limited. Two kinds of situations, however, may create difficulty. In the first place, in countries in which the absorptive capacity is very low because of shortages of entrepreneurship, labor skills, and administrative talent, certain large projects such as dams and irrigation works may still be carried out, although at great cost, by importing personnel along with capital.

Such expensive projects can be excluded from assistance programs only by applying a requirement

for eligibility that there must be a certain level of local participation in every enterprise—a condition desirable in any case on other than narrow grounds of economy. More thought must be given to how this condition can be stated so that it will be acceptable to the underdeveloped countries.

In the second place, the difficult question arises of when a country is to be regarded as having passed far enough out of the underdeveloped category to justify denial of further economic aid. Absorptive capacity gives no guidance here since, as development proceeds, the capacity to absorb capital expands indefinitely. The proper test is whether the country has reached a growth stage where it is able to mobilize out of its own resources sufficient saving and investment to maintain a reasonable rate of expansion of per capita income. The problem here is what criteria to use in deciding what rate of saving from its own income a country can reasonably be expected to achieve. This will depend on the political structure as well as on the economy of the country. Further work needs to be done on alternative methods of testing the adequacy of a country's own efforts in its own behalf.

Political Obligations

The third problem, that of the wisdom and necessity of political obligations, is more complex than it is sometimes made to appear. Certainly economic assistance is not an effective instrument for securing from the government of an underdeveloped country short-term adherence to foreign policy positions preferred by the United States. But if the central goal of an economic-assistance policy is to foster the kind of political evolution abroad that is desirable to world security, do we not have to examine carefully the kinds of economic assistance under what conditions will have this effect?

To some degree, the conditions for the economic productivity of an investment will be the same as those applicable to assure a desirable political evolution. Such criteria as personnel selection by merit, the broadest participation in decision making, and encouragement of the maximum upward mobility of all classes can be justified on economic as well as political grounds. It is doubtful, however, whether economic criteria will suffice to exclude all situations in which aid programs might contribute to what from the American point of view would be an undesirable political evolution. Further consideration must be given to whether additional political criteria can be formulated in such a way as to be broadly acceptable to recipient countries.

Economic and Military Aid

With regard to the fourth proposition concerning the broad categories of aid, there is no question but that in the so-called "uncommitted countries" the economic aid program has suffered from being too closely identified in the minds of the "uncommitted" peoples with military aid. There is also a suspicion, on the other hand, that the programs in those countries where we are supplying military aid suffer from the opposite weakness—namely, that military and economic aid are not sufficiently interrelated. In many cases, the principal purpose of military aid is to permit a foreign regime to establish conditions of reasonable peace and security within its borders by building an effective constabulary force. The ultimate sources of instability and discontent are, however, in many cases economic and political. In such cases, the constabulary will be a very much more effective stabilizing force if it is given constructive economic and social functions as well as strictly police functions.

American military aid has too frequently been administered without sufficient recognition of these constructive possibilities. These possibilities are likely to be recognized only if, in these areas, military and economic assistance are administered by the same organization. Thus, the central problem is to institute programs of military and economic assistance which are sufficiently separate in policy and concept to quiet the fears of the uncommitted countries and sufficiently integrated in administration to provide maximum progress toward objectives in countries where both forms of aid are required.

International Administration

The final problem of national versus international administration of aid is closely dependent on all of the considerations thus far presented. If economic growth anywhere were always in our interest, and if there were few if any situations in which political criteria would have to be added to economic ones, a strong case could be made that international administration, if efficient, would be in the American interest. Conversely, if there are a large number of situations in which both the magnitude and the character of assistance programs must be influenced by wise judgments about the impact of such programs on the political process, it is much more doubtful whether international administration would secure the desired results.

This question is illustrated nicely by the problem of administration in countries where the United States has major responsibilities for mili-

tary assistance. Military assistance presumably cannot be internationalized. Is it more important for economic assistance to these countries to be internationally administered, or is it more important for such assistance to be administered jointly with military assistance in such a way that the effect of both types is maximized?

Conclusion

The complexities underlying these five stated and discussed propositions can be reduced to some extent by considering their opposites as completely invalid. We can reject as acceptable concepts of American foreign aid any of the following: (i) that the United States has no interest in the economic growth of the underdeveloped areas; (ii) that if we undertake development assistance there is almost no limit to what we could be asked to spend on it; (iii) that we should use economic aid for short-term political purposes; (iv) that economic aid should be given only for military purposes; or (v) that we should handle our aid programs strictly bilaterally with no effort to put them into a multilateral framework.

In any case, the problems of the future of foreign aid are sufficiently extensive that they should stimulate full discussion and careful consideration of propositions which can be accepted with few reservations by the majority of the American public.

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Social Responsibility of the Physician

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"THE practice of medicine," writes Donald Fleming (*1*, p. 6), "is . . . a treaty with society." This is a fresh and startling phrase, and it cuts to the heart of the matter, for it asserts that medicine is, in its essence, a part of the one intricate social fabric that binds us all, personally as well as professionally. It is this fabric that unites us as men and dictates our responsibilities as human beings; and it is only within this social framework, similarly, that the physician (or the scientist, or the teamster, or the teacher) can assess his role and define his particular responsibilities.

It was the ability always to see medicine in this larger context that marked Ernst Boas' life and work, and it is proper that an article on social responsibility should commemorate this distinguished physician's career. Many physicians before him have championed the right of every person to good medical care without regard to income, race, or other social factors. Many have labored toward the extension and improvement of medical care. But it takes a larger vision always to recognize, as Boas did, that these issues are not internal to medicine, that the public health is the net result of a battery of forces ranging from biological selection, through medicine, to cultural evolution, and that medicine is but one of many disciplines that are working on different aspects of a larger problem.

Medicine as Human Ecology

What is this larger problem? It has been best defined, I think, as human ecology—man's relationship to his natural and social environment and the political and economic action he takes to improve his position.

How can we define the physician's share of this problem? It has been phrased, in one quarter (*2*), in immediate and practical terms: "How to make integrated health service available to people of all social and economic groups, keeping step with them throughout their life span, taking full account of their relation to their environment, both human and physical, and bringing coherence and continuity into their contacts with professional services and facilities?"

Yet, sweeping as this seems, it is not broad enough. It conceals still more fundamental questions: What is the real nature of illness—the "whole natural history of disease in human communities as well as in individuals" (*3*, p. ix)? What is the relationship of ill health and social circumstance? How does the individual integrate the many aspects of internal and external environment to keep a healthy equilibrium? What are "the needs, interactions, disabilities and potentialities of human beings living in social aggregates" (*4*)? Of the many health and medical needs, which are the most pressing?

No one in medicine—certainly not the medical student—has full answers to these questions. Perhaps it is most important now, for student and practitioner alike, to realize that the questions are always there, in every ward and clinic and doctor's office, written urgently between the lines of every medical history, waiting to be answered.

And perhaps it is equally important to remember (as Boas always remembered) that there is bitter substance behind these generalizations. Human tragedy and inhuman misery cry out behind the smooth, impersonal talk of "human ecology" and "social responsibility." At a clinical demonstration during my first few months in medical school, the teacher wheeled in the hour's first patient, a 17-year-old boy. The subject under discussion was paraplegia. The boy was, indeed, paraplegic, and

this was discussed learnedly and at some length. He had a bullet in his spine. No one dwelled on the observation that he had lived all his life in Cleveland's Negro ghetto and that he was shot when he tried to rob a grocery store at gun point; no one suggested that he had had urgent and unmet health needs long before his spinal cord was severed. These were not "medical" considerations; the medical answer to "what caused this?" was "a bullet."

At the time we saw him he was receiving the best medical care—the most skilled surgery, the most patient physical therapy, the most sympathetic emotional rehabilitation. No one suggested that it was too late, that the case was already lost, that "medical care" had failed him at some point before he reached the hospital. If questions are difficult to answer, it is convenient to leave them unasked.

For the physician who sees such failures as part of his responsibility, then, there is a question that precedes the recognition that every person has the right to good medical care. This question is "What *is* good medical care?"

Quality of Medical Care

Half a century ago, Abraham Flexner toured the nation's medical schools for the Carnegie Foundation and published the now legendary report (*5*) that led to the establishment of effective social control over medical education and to the collapse of diploma mills, haphazard teaching by apprenticeship, and the worst of the medical cults. Since then, "modern medicine" in the United States has meant "scientific medicine" in the tradition that William H. Welch, the great transitional figure in American medicine, brought back from Germany to the Johns Hopkins Medical School: a medicine based on laboratory research in the basic sciences, on the introduction of scientific method into clinical practice, and on the search for specific etiologic agents of disease, specific pathologic processes, and specific chemotherapeutic or preventive weapons.

It drew first from the tradition of Koch and Pasteur and von Behring, and then from Ehrlich. In its first few decades it traced out the bacteriological "causes" of tuberculosis, typhoid, cholera, gonorrhea, and a dozen others; it yielded antitoxins and antiserums, and, ultimately, the antibiotics. Later, making rich use of basic research in physiology and biochemistry, it made significant inroads on the metabolic diseases.

It produced a type of medical practice that was oriented around the single question, "What does he have and what is good for it?" It answered the question so often and so successfully that it added decades to the average life-span and produced what is usually called a "golden age" in medicine —scientific medicine, with specific etiology and specific cure as its touchstones, specialization as its dominant pattern, and medical centers packed with complex diagnostic and therapeutic equipment as its preferred instrument.

And yet, as Galdston (*6*) has pointed out, this kind of modern medicine has failed, despite "the indisputable reality and the undeniable effectiveness of these triumphs." The admission that diseases often have multiple etiologies, internal and external, and the grudging absorption of a few of the insights of dynamic psychiatry, two decades ago, were the first signs of the recognition that modern medicine, in the sense of narrowly "scientific" medicine, was not enough. And this is the key to what is meant by "failure"—not that what was accomplished was wrong but that the field of vision was too narrow. Galdston, who has marshaled the case against "scientific" medicine with eloquence and a keen sense of history, explains (*6*): ". . . what is challenged and what is questioned are not the demonstrated existences of bacteria, toxins, antitoxins, chemotherapeutic specifics, antibiotics and the like. What is questioned . . . is the contention, always implied and often expressed, that bacteria and other specific noxious agents, toxins, antitoxins, chemotherapeutic agents, antibiotics and all the other items in the armamentarium of etiological medicine represent and embrace all that is pertinent to the comprehension, diagnosis, cure and control of disease."

In the face of such criticisms, and with the growing impact of psychiatric knowledge on pediatrics and internal medicine, thoughtful physicians who were concerned with the quality of medical care turned away from medicine's expanding scientific periphery and rediscovered its core, the relationship between doctor and patient. Emphasis was placed on viewing the patient as a total organism, a whole man, something more than a diseased liver or a fractured limb. Patients, the medical schools once again emphasized, were persons, not "cases" isolated in space and time, and to know a patient well, one must know something of his place in life, his family, his neighbors, and his pattern of living.

In a description of "the changing physician" (*7*), a distinguished professor of clinical medicine characterized today's good doctor as "a scientist at work on a complex single human being. . . . Concern with the whole personality inevitably uncovers human facets that evoke the compassion which is so necessary for good medical care."

Is this, then, what we mean by good medical

care? Certainly, it is a long step upward from the fragmented patient to the whole person, sympathetically and perceptively regarded as something more than merely somatic and more than merely psychiatric. But, if physicians are to discharge their social responsibilities, to meet the challenge of patients like our 17-year-old paraplegic, to "take full account of their relation to their environment both human and physical," this is not enough.

Medicine and the Human Community

John A. Ryle, one of a group of English physicians most concerned with broadening medicine's scope, said, in *Changing Disciplines* (*3*, pp. v, vi): "Looking back, it has seemed to me that, while medicine—through scientific and technical advances—has greatly gained in potentiality during the past quarter of a century, it has, in the process, become less surely attuned to some fundamental human needs—to the deeper personal needs of the individual *and to the broader social needs of the group or community* [italics added]. Reforms which should be a particular concern of medicine are still overdue or have found their chief support elsewhere . . . we are still, as a profession, thinking more about curing than preventing, more about medical care and its huge costs than about the economies which could be effected by attacking the basic causes of disease . . . we [must] no longer believe that medical truths are only or chiefly to be discovered under the microscope, by means of the test-tube and the animal experiment, or by clinical examination and increasingly elaborate pathological studies at the bedside. . . . I have transferred my energies . . . from studies in individual pathology to studies in social pathology."

The heart of what Ryle is trying to express, I think, extends beyond medicine and the individual patient. It is a sense of discontinuity between medicine and a society in which endless social change, new social needs, and fresh patterns of social interaction swirl constantly around—and within—its individual members.

The road that Ryle points out is the only road, I submit, that medicine can follow if physicians are to discharge their social responsibility—which is simply to weave medicine back fully into the common social fabric. It is the only road that goes beyond the bullet in a boy's spine to prior causes; that regards pellagra as "caused" by depressed socioeconomic conditions rather than by a vitamin deficiency and sees both of these aspects as properly medical; that regards social problems, insofar as they have any bearing on the health of the person or of the community, as part of the physician's active professional interest. There is something wrong with the kind of medicine that can, for example, deliver—with superb technical skill—the sixth or seventh child to a family in a New York slum area that is surrounded by hostile neighbors, yet turn away with indifference (by calling such considerations "nonmedical") from the effects of that social environment on the infant, from any interest in the complex of economics and emotions and cultural patterns that will affect its health, from any awareness, even, that the family has attitudes about living in a ghetto that affect its health and that the families living just outside the ghetto's borders have fears and attitudes that affect their health, too.

Social pathology provides, perhaps, the clearest examples of the territory that good medical care must incorporate; but I do not mean that good medicine is to be achieved simply by the addition of social pathology to its interests. The same kind of social analysis is a part of medicine's responsibility to every individual, in whatever social circumstances, throughout his life-span; it must recognize always that an individual is not simply "in" an environment but is a functioning part "of" his environment and must realize that his environment consists, in large part, of other men, and that men live in social aggregates.

This is a new kind of medicine, and it will require the incorporation of new skills and techniques—not just those of psychiatry but those of sociology and anthropology as well. Medical science has produced great treasures of knowledge about the structure and behavior of living things, from microorganism to man, by applying the techniques of the biological and natural sciences to the universal cycles of reproduction, growth, development, and aging. The time is ripe now for a next upward step in our understanding of man—of his adjustment to his world and of his health—by bringing to bear on medical problems the procedures and techniques of analysis of the social sciences, insofar as we can.

On what kinds of medical problems? On all those that the physician now regards as properly medical (and is beginning to examine by means of longitudinal studies) and on new ones as well: delinquency, aging, racial conflict, the clash of cultural patterns and technical change, the impact of social circumstance on disease, and the impact of medical progress on social structure. All these affect health as we now define it. And others are just over the horizon: the increased leisure and altered living patterns that may come with automation or the growing pressures of overpopulation, to name but a few.

Does all this mean that we must now train doc-

tors to be competent economists, sociologists, political scientists, and anthropologists? Of course not, nor is there any intention that the doctor should be some sort of social engineer or social pathologist, writing prescriptions for a sick society (whatever that is).

It does mean, however, that the physician should be able to perceive the social aspects of health and disease in the lives of his patients and that he should have at least as much understanding of the methods, techniques, lines of thought, and limitations of these fields as he has, say, of radioisotopes—enough, that is, to keep on learning, to adapt, and to evaluate as they provide new tools for his practice and as the changing social fabric presents him with new medical problems. And it opens to the physician the rich rewards of a new kind of clinical epidemiology in his daily practice, an epidemiology that is concerned with social relationships and group identifications in connection with health and illness. Too many physicians approach their patients, and their patients' environments, convinced—like 19th-century physicists—that, basically, they know in advance where their efforts will lead them, that the fundamentals are already clear, and that only the details remain to be investigated. As long as disease, or the threat of it, is the only excuse for doing something for the patient, social factors that *appear* to have no relevance to disease will be ignored, and new insights will be missed.

In particular, this will call for an understanding on the physician's part of cultural and subcultural differences in American society. What is recognized as disease or illness is a matter of cultural prescription, and a given biological condition may or may not be considered an illness. What people do in the face of illness, how they do it, and when, are determined by the "knowledge" they have of the meaning and cause of their symptoms and of what can or should be done about them. Such knowledge is a product of association with other people—that is, of culture—and this varies in different economic, ethnic, nationality, and social-class groups (*8*).

The sensitive physician will have to understand these diversities and have some knowledge of the cultural or subcultural orientation of his patient and an awareness of the extent to which these values, beliefs, and behavior patterns influence the patient's attitudes toward illness, medical care, and the physician himself. The mother who rejects prenatal care, the young man who deserts a tuberculosis ward to rejoin his family, the parents who refuse to concede that their child has a congenital defect—these medical failures are, more often than not, ascribed to individual ignorance, apathy, or perversity when, in fact, as Saunders (*8*) points out, they stem from failure to understand cultural patterns.

Finally, the physician will have to learn to understand himself—to realize that he, too, is a creation of his culture and subculture, and that, in addition to technical knowledge and practical skills, he carries with him, everywhere, an enormous cultural baggage of ideas, attitudes, value judgments, beliefs, and preferences which influence his work. To be able to recognize these objectively is a moral obligation; it should be a professional necessity as well, so that the physician can say, in the words of Terence, "I am a man, and therefore nothing that is human is alien to me."

Clearly, this kind of medicine, and such physicians, are goals for the future rather than realities capable of immediate achievement. Some of these goals we must leave to the medical schools, medicine's surest vehicles for bringing about change and progress; some can come only by cooperation, individually and through organized medical groups, with other disciplines. If this spells an end to that remarkably arrogant occupational ethnocentrism whereby doctors sometimes regard themselves as sole arbiters of the public health (and dismiss all others as "the laity")—why, so much the better. If it leads the physician into new roles, so much the better. It is time that "reforms which should be a particular concern of medicine" lead doctors to be reformers. If physicians can fight for sanitary codes and compulsory vaccination or can testify as to the maximum permissible number of bacteria in the municipal water supply, then they can, with equal propriety, speak up about the effects on health of racial discrimination or testify before town planners with respect to the minimum permissible number of square feet of green grass per growing child. And they can call these efforts by their proper name: good medicine.

Distribution of Medical Care

A full decade ago, the New York Academy of Medicine's Committee on Medicine and the Changing Order conceded (*9*) that "advances in medical science have outpaced the distribution of its benefits" and went on, wisely, to point out that "it is not *the* problem of medical care, but many problems, involving different types of service, distinct groups and localities, varying public attitudes, professional views and scientific standards."

The experiences of the 10 years that followed prompt a question. If there are many problems, then why are there not many solutions—or, rather, why are there not many possible solutions under active (but responsible) experimental test, in an

atmosphere of boldest trial and freest inquiry? Why has it been so difficult to set up the social experiments that would let us see, for example, what the partnerships of labor unions and physicians, or farmers and physicians, or physicians and local governments (in limited areas in which it might seem appropriate) can accomplish in distributing varieties of medical care to selected groups? Why has almost every change and innovation (including voluntary prepayment insurance and group practice, which are now so fervently endorsed) been greeted initially with such passionate opposition, with voices of orthodoxy thunderously implying that the status quo—*any* status quo—has both Divine and Hippocratic sanction?

One reason, I suspect, concerns the individual practitioner. Medicine is a way of making money. It is many other things, of course, and this is not its first concern, but the matter of money is there. Some of the units and some of the spokesmen of organized medicine seem, on occasion, to wish that it were not, and this provokes a painful dualism in their relationships with the public on questions of the availability and modes of distribution of medical care. On the one hand, some such groups repeatedly make statements (pro or con) on new medical-care proposals that sound as if the economic consequences to the individual physician (and patient) were the last thing on their collective minds, instead of being a perfectly proper facet of the subject. On some other occasion, the same groups may blatantly demand the application of a pauper's oath as a prerequisite to coverage under a public health measure.

Nowhere has this dualism been better demonstrated than in the recurring debate over socialized, government-operated medicine. There are, I believe, many sound reasons for opposing most such schemes, and there is no need to repeat them here, but it seems ludicrous, if not dishonest, that responsible medical groups should address themselves repeatedly to the public on this question without once firmly declaring that one of the reasons for their opposition—not the most important reason, not the most serious, but one reason—is fear of the consequences to physicians' incomes and preferred working arrangements. No one who has had the opportunity to note the contrast between physicians' public discussions of the issue and their discussions with each other could miss the point.

The truth, of course, is that the physician's interest in making money is a perfectly legitimate private aim. But because it touches on health, a matter of public concern, it is a private aim of public consequence. The physician's interests as an entrepreneur coexist with his activities as a healer and a social servant, and both must ultimately be subject to some degree of social regulation; there is no justifiable way of exempting one or the other so long as both the costs and quality of medical care remain social problems. But physicians can at least make intelligent solutions more likely by moving the question of their financial reward into the arena of open discussion.

A second reason for the resistance to change and innovation is the fact that medicine is itself a social institution—a vast complex of knowledge and techniques, attitudes and roles and customs, equipment and instruments, bricks and men, all interlocking to form a mutually reinforcing system. Like all other major institutional complexes —government, religion, the family, education—it is too intricate, too entrenched, and too important to submit to easy change.

In the face of these difficulties, we find today a great lack of social experimentation (for one cannot be honestly experimental and also sure of the results) and, inevitably, a great dearth of fresh ideas, masked behind an overabundance of debate. The failure to permit experiment is a serious charge against scientists, and physicians are scientists. It is as serious in this area as it would be in the basic medical sciences, of which Wilfred Trotter (*10*) long ago commented: "It is poverty rather than fertility of ideas that causes them to be used as a substitute for experiment, to be fought for with prejudice or decried with passion . . . when ideas are freely current they keep science fresh and living. . . ."

Certainly there have been sincere and conscientious men among the opponents of almost any given proposal for objective experiment in the distribution of medical care. But there have been others who were motivated chiefly by fear. And "how simple it is," Trotter also points out (*11*), "when fear is afoot, to block the path of the new idea by unbelief and call it skepticism, and by misunderstanding, and call it suspended judgment . . . fear can with inimitable art disguise itself as caution, or sanity, or reasoned skepticism, or on occasion even courage."

Perhaps it would be easier for today's physician to encourage and take part in experimentation that departs from the status quo if he remembered more clearly that he himself is the product—in the disciplines he uses and in the training by which he acquired them—of an earlier radicalism and discontent.

When Welch organized the first thoroughly scientific school of medicine in the United States, at the turn of the century, he had, his biographer notes (*1*), "a deep and overriding intellectual commitment to rebellion against the status quo in medicine and medical instruction." And he met

opposition. Rigid requirements for admission, a graded curriculum, scientific research in laboratories attached to the school, hospital teaching controlled by the medical faculty, a full-time faculty —all were attacked as untried experiments which might fail. All were attacked as doctrinaire and impractical. All were accused of being depersonalizing and destructive of human relationships. There is a certain familiarity in the charges.

I know of no panacea for the problems of the distribution of medical care. I can conceive of no other path to their solution than open, unfettered, but responsible experiment by communities and community organizations, by physicians and their professional organizations. Freed from the heavy hand of conformity and the fear of professional rebuke, we might be more willing to learn from the scattered but significant experiments already launched, here and abroad. Their number, happily, is growing—a group-practice plan in New York, a regional hospital network in Rochester, a rural community health center in New Jersey, an industrial health plan in California, union-sponsored health insurance and hospitals in the Midwest and South, and an experiment in government-and-private-practice partnership, the Uusimaa Field Demonstration Area in rural Finland.

I do not know how well any of these experiments work, or whether they work at all, but I believe that the effort that is now being expended in vehemently attacking, or emotionally defending, these attempts could better be devoted to objective study of their results, their advantages and shortcomings, with an eye, as well, to whatever they reveal about the changing health needs of the public. Let us learn what we can and try again. We are not forever compelled, as the Commonwealth Fund has noted, to equate scientific medicine with specialization as it is now exhibited, or comprehensive medicine with any of the existing varieties of general practice.

In the narrowest focus, then, the physician's social responsibility is inextricably tied to his conception of the patient, to his ability to realize that man is (in Alexis Carrel's phrases) more than the corpse dissected by the anatomist, the consciousness observed by the psychologist, the community of cells and fluids studied by the physiologist; for the patient is also the economic man, the family man, the minority- or majority-group man, the poet, the hero, the sinner or the saint—the troubled, complicated, groping, magnificent, and utterly unique human individual (*12*).

But there is a broader focus, and medicine shares it with all of science. Just as there are social aspects of medicine, so there are of science. Just as the costs of establishing and maintaining an effective medical structure and of training and paying physicians are social problems, so are the costs of scientific research and training. Just as social needs and social policy ultimately guide the direction of the scientist's work, so do they present the physician with new medical problems and new concepts of health and illness. And, just as technologic and scientific advances (for example, atomic research) can have enormous social impact, so can medical progress (for example, in the conquest of infectious disease with subsequent increase in population and life-span) produce new and urgent social problems.

We can, if we venture ahead in both the quality and distribution of medical care, make medicine more than a science of disease, more than a science of personality, more than a science of society; we can make it a science of the whole man "in relation to his environment both human and physical," a human ecology. We cannot do it alone; the inevitabilities of biological and social change will be the chief determinants of the new medicine. But we can enrich it and guide it, constantly unraveling and weaving anew the strands that bind medicine to the rest of the changing social fabric. Few responsibilities could be heavier, but no task could be more rewarding.

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Minimum Earth Satellites as "Storm Patrol"

S. F. SINGER

Dr. Singer, who is associate professor of physics at the University of Maryland, holds the degree of bachelor of electrical engineering from Ohio State University and master's and doctor's degrees in physics from Princeton University. From 1946 to 1950 he was connected with the Johns Hopkins University Applied Physics Laboratory at Silver Spring, Maryland. There he engaged in high-altitude research, in sea-level cosmic-ray experiments, and in cosmic-ray balloon measurements. In the course of this research, he took part in two Navy operations in the Arctic and in shipboard rocket launchings at the equator. As scientific liaison officer with the Office of Naval Research at the U.S. Embassy in London, from 1950 to 1953, Dr. Singer studied European research programs in these fields. At the University of Maryland he has been engaged in research on the origin of cosmic rays, the age of meteorites, and magnetic storms and aurorae and in the design of artificial satellites, small sounding rockets, and rocket instrumentation. He is a member of the technical panels on rockets and cosmic rays of the U.S. National Committee for the International Geophysical Year. This article is based on a paper that was presented at the tenth anniversary meeting of the Upper Atmosphere Rocket Research Panel, Ann Arbor, Michigan, 26–27 January 1956.

OF all the many scientific applications suggested for artificial earth satellites, the application to meteorology may have the most far-reaching importance for all of us. The earth's weather affects all phases of human existence and, therefore, also our national income and way of life. This influence extends not only to the farmer and the food processor but to many of the major industries, such as fuel oil, construction, farm implements, clothing manufacturers, and even resort operators.

The importance of a satellite for meteorological purposes is derived, of course, from its position. From the "top of the atmosphere," it surveys the earth beneath it, and, since it can cover the globe in a pole-to-pole orbit, it can survey the oceans, polar regions, and similar inaccessible places.

Since weather is a global phenomenon, observations on a global scale are obviously required. Wexler (*1*) was the first to suggest very specifically the use of a satellite as a "storm patrol." It would orbit at an altitude of 4000 miles, high enough to view a continent, and would carry a television camera. While such a system would be capable of a high resolution, higher actually than is necessary for meteorological purposes, a system of lower resolution would require a less elaborate data-transmission and data-reduction system and could be realized with a "minimum" satellite. I therefore wish to evaluate here the application of a minimum satellite (altitude 200–300 miles), carrying only a simple photocell, to the problem of recognizing meteorological features and observing their time variation in position and intensity.

One or more of these simple satellites in pole-to-pole orbits could act as a storm patrol and could also give other weather data on a continuous, world-wide basis (*2*). Such a program is feasible today, not only because we are building satellites, but also because we are developing the techniques to handle the tremendous inflow of satellite data with high-speed computing machines. We can confidently anticipate not only more reliable day-to-day weather prediction but also more precise long-range forecasts as well, even seasonal predictions for various regions of the world. Such is the aim of the present school of meteorologists. And, as the late John von Neumann has pointed out, from our better understanding of the weather it may be only a short step to its control.

It seems surprising, at first glance, that the resolution of a photocell is in any way comparable to that of a television camera. But the photocell in a minimum satellite operates at low altitudes. The photocell scheme, therefore, may be compared to taking a picture, not with a camera but with an exposure meter which scans the object from a very close distance. Hence, it conveys the same amount of meteorologically useful information that the television camera does, but in a much longer period

of time. The usefulness of the photocell as compared with the TV camera method derives from three facts: (i) it is technically much simpler and therefore more immediately feasible; (ii) the time scale for changes in weather patterns is long enough so that the increased time required to collect the information is of no particular disadvantage; and, most important (iii) the resolution required to recognize meteorological features can be quite coarse. It certainly need not be better than 10 miles and perhaps no better than 100 miles.

In order to improve the resolution, we can always use a number of photocells (Fig. 1). Also, the resolution can be made quite narrow in the direction of motion of the satellite by reducing the smoothing of the photocell signal. The photocell will then effectively view a strip of the earth instead of a circular area.

We can now compare the two schemes experimentally by seeing how the North American continent looks to a television camera (Fig. 2), to a four-photocell arrangement (Fig. 3), to a two-photocell arrangement (Fig. 4), and to a single photocell (Fig. 5). Wexler (*1*) constructed the picture shown in Fig. 2 (which represents the North American continent as seen in a hypothetical 4000-mile-high television camera over Amarillo, Texas, on 21 June, at noon) in the following manner.

Surface features of the earth were drawn in. Wexler used normal illumination values, standard albedo (4 percent for ocean, 15 percent for land) and took account of atmospheric scattering and depletion in both directions. Next, the atmospheric contribution was added—that of a "uniform diffuse reflector." Finally, a cloud pattern was added, with proper albedo values assigned to each cloud type, to show the following atmospheric disturbances: (i) a cyclone family of three storms in various stages of development, extending from Hudson Bay southwestward to Texas; (ii) the northeastern part of another such cyclone family, whose oldest member is in the Gulf of Alaska, the remaining members, to the southwest, being invisible; (iii) a fully developed hurricane imbedded in "streets" of trade cumuli in the West Indies; (iv) the Intertropic Convergence Zone (or Equatorial Front)—a zone of interaction between the northeast trade winds of the Northern Hemisphere and the southeast trade winds of the Southern Hemisphere—extending west of the Isthmus of Panama to the mid-Pacific; (v) a "line-squall"—favorite breeding ground of severe wind storms and tornadoes—in the eastern United States, moving ahead of the cold front and surrounded on both sides by the cauliflowerlike cumulus congestus; (vi) scattered cumulus clouds of varying thicknesses over the heated land areas, especially in the mountains and other areas where dynamic effects encourage the lifting of air in vertical columns; (vii) alto-cumulus-lenticularis, or lens-shaped, clouds formed by the lifting of layers of moist air over mountains and usually found where the "jet stream" crosses mountains, as over the northern Canadian Rockies; (viii) low stratus and fog, found off the southern and lower California coasts and over the Great Lakes and the Newfoundland area, formed by passage of warm, moist air over cold surfaces.

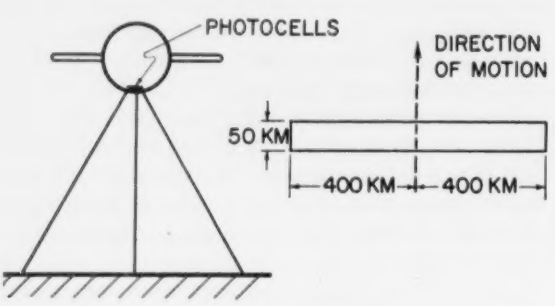

Fig. 1. Example of a photocell arrangement in an earth satellite, illustrating a typical resolution for a two-photocell system.

We shall now investigate which features are still recognizable in Figs. 3, 4, and 5; these represent pictures taken from a minimum satellite (*3*). With the resolution 200 kilometers (E–W) times 25 kilometers (N–S), the features clearly visible in Fig. 3 are i, ii, iii, iv, vii, and viii; the features moderately visible are v and vi. With the resolution 400 kilometers (E–W) times 50 kilometers (N–S), the features clearly visible in Fig. 4 are i, ii, iv, vii, and viii; the features moderately visible are iii and v; barely visible is feature vi. With the resolution 800 kilometers (E–W) times 50 kilometers (N–S), the features clearly visible in Fig. 5 are i, ii, iv, and viii; moderately visible is feature vii; and the features barely visible are iii, v, and vi. We note also that on all pictures the land areas and oceans can be clearly distinguished; snow cover would stand out.

In order to improve the brightness contrast, a filter should be used in front of the photocell to cut out the scattered light (mainly blue). Since the scattered light constitutes about 25 percent of the albedo (that is, 9 percent of incident light), the fractional contrast will be considerably improved, almost 100 percent.

The contrast

$$F = 2\,\frac{B_1 - B_2}{B_1 + B_2}$$

between land (average albedo 15 percent) and ocean (4 percent) will improve from

$$2\frac{0.15-0.04}{(0.15+0.09)+(0.04+0.09)}=0.6$$

to

$$2\frac{0.15-0.04}{0.15+0.04}=1.15$$

almost double. In order to distinguish two objects, F should exceed 0.1.

A brief description might be given of the method that was used to prepare these pictures. The resolution was set by assuming a photocell having a field of view of 800 kilometers at right angles to the satellite's motion and a better resolution along it (Fig. 5). The satellite is assumed to be in a pole-to-pole orbit and travels, therefore, in a nearly north-south direction. The details of the satellite orbit and instrumentation and further meteorologi-

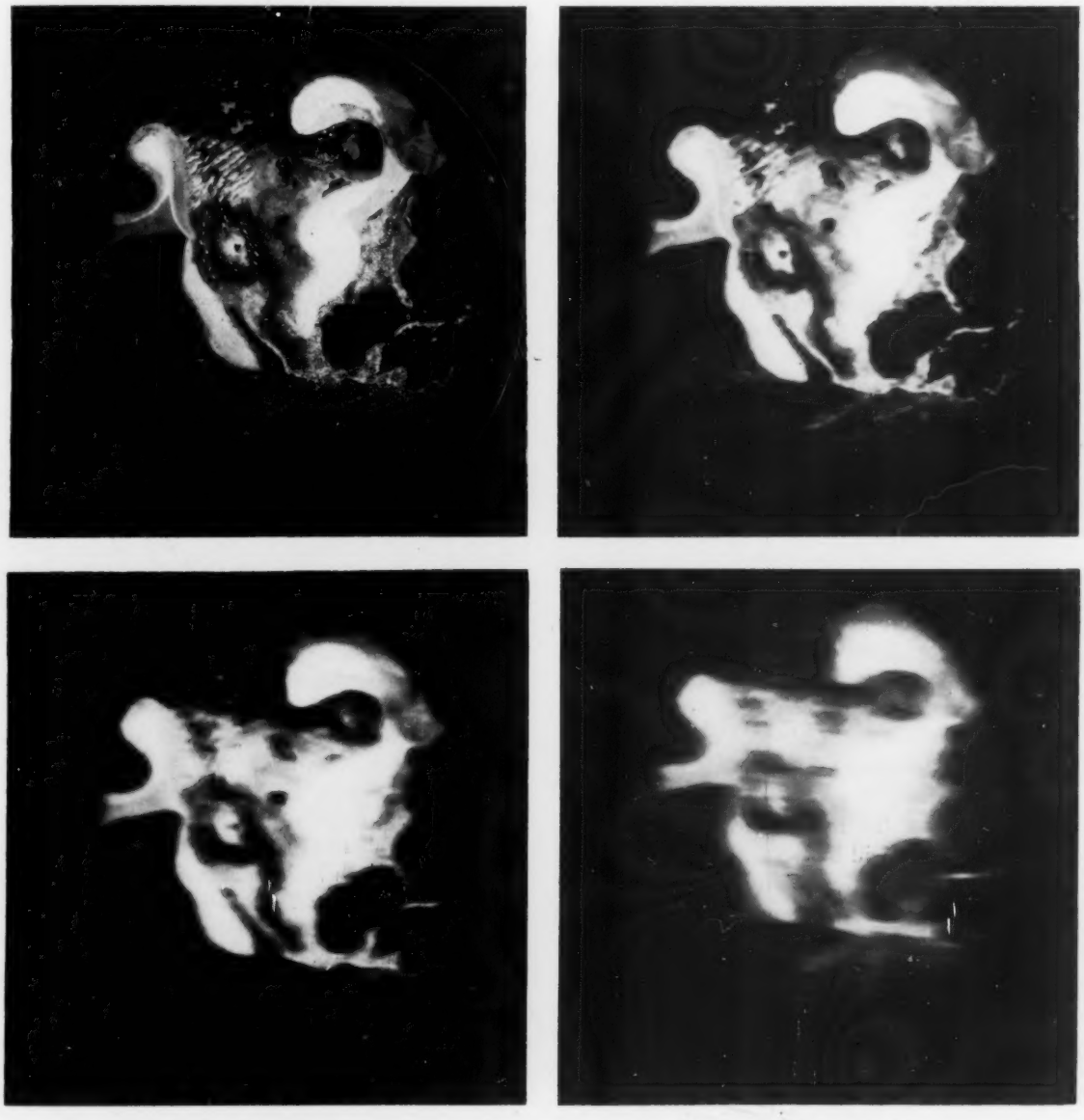

Fig. 2 (top left). View of the North American continent as it would probably appear in a television camera located in a satellite 4000 miles above Amarillo, Texas, on 21 June, at noon, under atmospheric conditions that could be expected to prevail on that date. [Courtesy H. Wexler] Fig. 3 (top right). The North American continent as it would appear under the same conditions if a four-photocell system were substituted for the television camera; Fig. 4 (lower left) if a two-photocell system were used; Fig. 5 (lower right) if a single photocell were used.

cal applications are discussed elsewhere (*2*, *4*). Next, we considered the use of two or four photocells to share the field of view, to obtain a better resolution. Figures 3, 4, and 5 were prepared in an enlarger; the negative of Fig. 2 was used and the printing paper was "rocked" the required amount in the east-west direction. Figures 3, 4, and 5 thus represent the results obtainable from a photocell after a large number of adjacent sweeps have been made. A single sweep will, of course, show no gradations in the east-west direction perpendicular to the satellite's motion.

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ASSOCIATION AFFAIRS

Hotel Headquarters and Housing, Indianapolis Meeting

The preliminary announcement of the fourth Indianapolis meeting, 26–30 Dec., of the American Association for the Advancement of Science [*Sci. Monthly* **85**, 41 (1957)], although it named the Claypool as AAAS headquarters hotel, the Marott as headquarters for the American Astronomical Society, and the Antlers as headquarters for the science teaching societies, was principally concerned with the programs of the 1957 meeting —as planned by all 18 AAAS sections and by some 66 participating societies. A list of the headquarters for each section and participating organization is appended, since it is an obvious convenience for each person attending the meeting to have this information before he applies for room reservations.

The center of the meeting will be the Murat Temple and here will be located the AAAS Main Registration-Information Center, the Visible Directory of Registrants, the AAAS Office, the AAAS Science Theatre, and the Annual Exposition of Science and Industry. The Murat Temple is within walking distance of all downtown hotels, but there will also be special AAAS buses that will operate at frequent intervals between the hotels and the temple.

The Claypool's large ballroom will be the site of the AAAS-sponsored general symposium, *Moving Frontiers of Science,* the evening of 26 Dec., but the second session of the general symposium will be in the Murat Theatre the following afternoon. The AAAS Smoker for all registrants, the evening of 29 Dec., will also be in the Murat Temple.

Housing

Beginning with this issue, the advertising section of *The Scientific Monthly* will carry, at frequent intervals, page announcements of hotel sleeping accommodations and their current rate schedules, together with a coupon which should be filled out and sent, *not* to any hotel directly, but to the AAAS Housing Bureau in Indianapolis. (Members of the American Astronomical Society, however, are asked to reserve their rooms in the Marott Hotel, 2625 N. Meridian St., by direct correspondence.)

All applications for hotel rooms will be filled in the order of their receipt. Those who apply early are assured of the hotel of their first choice if the stated desired and maximum rates are within the limits of the printed rate schedules. In Indianapolis, which is accustomed to accommodating the large attendance at the automobile races, there is an adequate supply of rooms at a wide range of rates. It would be well to consider, however, that, as in any city, the supply of single rooms at minimum rates is relatively limited and that higher priced single rooms and double rooms for single occupancy are more plentiful. Thus, it is suggested that the *maximum rate,* which you do not wish to exceed, and your *desired rate* both be stated on your coupon. Room expenses usually can be reduced substantially if rooms are shared by two persons or if suites are shared by three or more persons. Also, upon re-

quest, most hotels will place comfortable rollaway beds in rooms or suites at $2.50 to $3 per night.

Registration

Both the technical, or program, sessions and the special sessions are open to all interested persons. Although registration for these is not mandatory, it is expected that all who attend will wish to pay the AAAS registration fee of $3 and thus contribute a proportionate share of the heavy expenses of the meeting.

Each registrant receives the book-size General Program-Directory (a valuable reference on all AAAS activities), convention literature, listing in the Visible Directory of Registrants, and a Convention Badge, which insures all privileges of the meeting. The badge *is* required for admission to the large-scale exhibits, the AAAS Science Theatre, the presidential address and reception, and the AAAS Smoker; refreshments are served at the last two events.

Advance registration has some decided advantages: delay at the registration desks upon arrival is eliminated; the General Program-Directory, which is sent by first class mail early in December, enables one, at leisure, to determine which events and sessions he particularly does not wish to overlook; and one's name is posted in the Visible Directory of Registrants as the meeting opens (hotel room can be added later by the registrant himself).

An announcement on advance registration and a coupon for this will also be found in the advertising section of this issue and at intervals hereafter.

Hotels

Note: Societies are grouped in the same sequence of disciplines as the letters of the AAAS sections.

Claypool (600 rooms), Washington and Illinois Sts.: AAAS; Press; AAAS Sections F–Zoological Sciences, G–Botanical Sciences, M–Engineering, and N–Medical Sciences; American Society of Zoologists, Society of Systematic Zoology; American Society of Naturalists, Beta Beta Beta Honorary Biological Society, Biometric Society, Eastern North American Region, Ecological Society of America, Genetics Society of America, Society of General Physiologists; American Society of Plant Physiologists, Botanical Society of America; Engineering Manpower Commission; Alpha Epsilon Delta, American Association of Hospital Consultants, American Medical Association Committee on Cosmetics, American Physiological Society, American Psychiatric Association, Society for Investigative Dermatology; National Association of Science Writers, Scientific Research Society of America, Sigma Delta Epsilon, Society of the Sigma Xi, United Chapters of Phi Beta Kappa.

Sheraton-Lincoln (400 rooms), 117 W. Washington St.: AAAS Sections H–Anthropology, I–Psychology, K–Social and Economic Sciences, and P–Industrial Science; American Economic Association, American Political Science Association, American Sociological Society, American Statistical Association, Metric Association, National Academy of Economics and Political Science, Pi Gamma Mu, Society for the Advancement of Criminology; American Industrial Hygiene Association; Conference on Scientific Manpower, National Academy of Sciences–National Research Council, National Science Foundation, Scientific Manpower Commission.

Antlers (200 rooms), 750 N. Meridian St.: National Association of Biology Teachers; Society for Research in Child Development; National Association for Research in Science Teaching, National Science Teachers Association; American Nature Study Society, National Foundation for Junior Museums.

Continental (300 rooms), 401 N. Meridian St.: AAAS Sections A–Mathematics, B–Physics, and E–Geology and Geography; Association for Computing Machinery, National Council of Teachers of Mathematics; American Meteorological Society, Sigma Pi Sigma; Association of American Geographers, Geological Society of America, National Geographic Society, National Speleological Society; AAAS Cooperative Committee on the Teaching of Science and Mathematics; American Geophysical Union.

Severin (400 rooms), 201 S. Illinois St.: AAAS Sections C–Chemistry, Nd–Dentistry, Np–Pharmacy, and Q–Education; Alpha Chi Sigma, American Chemical Society; American College of Dentists, American Dental Association, International Association for Dental Research; American Association of Colleges of Pharmacy, American College of Apothecaries, American Pharmaceutical Association, Scientific Section, American Society of Hospital Pharmacists; American Educational Research Association, International Council for Exceptional Children, National Association for Gifted Children; Academy Conference.

Warren (250 rooms), 123 S. Illinois St.: AAAS Section L–History and Philosophy of Science, Philosophy of Science Association, Society for General Systems Research.

Washington (300 rooms), 34 E. Washington St.: AAAS Section O–Agriculture; Association of Technical Writers and Editors, Conference on Scientific Editorial Problems.

Marott (250 rooms), 2625 N. Meridian St.: AAAS Section D–Astronomy, American Astronomical Society, Astronomical League.

Junior Academies of Science

A Conference on Junior Academies of Science was held in Chicago, 15–16 Feb. This conference was jointly sponsored by the Academy Conference of the American Association for the Advancement of Science and the Museum Division of the Oak Ridge Institute of Nuclear Studies and was supported by a grant from the National Science Foundation. The Undergraduate Division of the University of Illinois, Navy Pier Campus, acted as host.

Seventy-seven persons registered. The first general session was presided over by Dewey Large. It consisted of an address of welcome by Charles C. Caveny, responded to by P. H. Yancey; "Backgrounds and objectives of the conference with respect to junior academies in the American Association for the Advancement of Science" by Raymond L. Taylor; "Status of junior academies of science" by Thelma C. Heatwole; and a briefing of concurrent sessions by Yancey.

The first general session was followed by a luncheon presided over by Harold W. Bailey. Charles G. Wilder of ORINS introduced the speaker, E. T. McSwain, School of Education, Northwestern University, who spoke on "Opportunities in secondary education."

The second general session was presided over by Yancey. Reports from the concurrent sessions were read and discussed, and the following proposals were made to the Academy Conference.

1) That the encouragement of young people in scientific investigation be the major interest of junior academies of science. This may be accomplished through the presentation of their work in science meetings, exhibits, or fairs, and such other activities as are consonant with the aims of junior academies.

2) That the Academy Conference of the AAAS be requested to establish a national clearinghouse of information for junior and senior academies, with adequate editorial and secretarial staff and necessary services, including publications and/or the use of appropriate existing publications. Furthermore, the Academy Conference is urged to explore ways and means of implementing the employment of a full-time junior academy field worker in each state.

3) That there be an annual meeting of representatives of junior academies. This would be held in conjunction with the Academy Conference at the AAAS convention.

4) That senior academies give greater recognition to deserving science teachers, and that, where possible and feasible, distinguished service awards be made to outstanding science teachers.

5) That the Academy Conference give suitable and appropriate awards to selected junior academies of science for outstanding performance and achievement.

6) That each junior academy of science be encouraged to develop a constitution and bylaws acceptable to the senior academy.

7) That junior academies should basically represent organizations of science clubs under the sponsorship of senior academies. Further, that the junior academy program should be a year-round activity, with science exhibits forming an integral part of the program.

8) That junior academy regional work conferences be held and that representatives of states not currently represented by junior academies also be invited to attend these conferences to obtain information on junior academies.

9) That a junior academy handbook be prepared and made available to science teachers. Such a handbook should include ideas for projects and for organizing and administering junior academy programs.

10) That the National Science Teachers Association, the National Association of Biology Teachers, and the American Chemical Society be urged to include in their convention programs a session concerned with the activities of junior academies of science.

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BOOK REVIEWS

An Introduction to Cybernetics. W. Ross Ashby. Wiley, New York, 1956. 295 pp. Illus. $6.50.

The intention of Ross Ashby is to introduce cybernetics to biological scientists and others without assuming any knowledge of mathematics beyond an elementary level. He feels that many workers who might profitably apply the techniques of this field to their own specialties do not do it because they assume that knowledge of advanced mathematics and electronics is prerequisite to doing so. In my opinion Ashby's attempt is definitely a success. Most of the important ideas are discussed, often in an original way. Numerous exercises (with answers at the end of the book) permit the reader to test his grasp of the subject matter and help fix it firmly in his mind.

The text reads well, even though the reasoning is often closely knit. Since many of the important ideas comprise elements at the core of much advanced mathematics, the reader unacquainted with those fields will have to read carefully and thoughtfully. It will do him good. It is a pity the author did not expand on those topics a little more for he would then have been able to dispel much fear of mathematics and encourage his intended readers to enter more deeply into the technicalities of the field.

The book consists of three major parts, entitled (in order) "Mechanism," "Variety," and "Regulation and control." In the first part (six chapters), the basic mathematical and logical concepts are introduced so simply that an unsophisticated reader would not realize that he has assimilated many of the basic abstractions of higher mathematics. Among these are sets, functions, operators, transformations, vectors, phase space, trajectories, stability, isomorphisms, and homomorphisms. Where does mechanism come in? A machine is the embodiment of transformation on a certain set of entities called the possible states, or phase space, of the machine; the succession of states in which it is found with passage of time is its trajectory. The general language of mathematics enables one to talk of *all* machines, not necessarily a particular one, and this is what the author does, to a considerable extent.

In the second part (three chapters), notions underlying the modern information concept are introduced. The presentation is clear, but I would quibble a little about terminology. The discussion is given in terms of "variety," with its measure, entropy, introduced only at the end. Transmission of variety, instead of transmission of information through a channel, is the basis of the development. It is not clear that introduction of a new term in place of the standard one yields any gain in clarity or intuitiveness. The standard terms have to be learned eventually, express the basic ideas well, are intuitive, and are suitable for introductory presentation.

In the final part (five chapters), regulation and control are treated in a fashion motivated by the needs of biology rather than of electronics. The ideas earlier developed are used throughout, and new ones are brought in (for example, regulation in biological systems, amplifiers, games and strategies, regulation in large systems). A small bibliography, which could be expanded with profit, closes the book.

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The Criminal, the Judge, and the Public. A psychological analysis. Franz Alexander and Hugo Staub. Free Press, Glencoe, Ill.; Falcon's Wing Press, Indian Hills, Colo., rev. ed., 1956. 239 pp. $4.

The increase of violent crime, with the average age of offenders getting younger and younger, has focused attention on the relationship between psychiatry and law. In present-day discussions three currents are discernible. The first includes the more conservative clinical psychiatrists, who match the rather strict definitions of the law with equally strict determinations of what constitutes mental illness in relation to the law. They comprise about 95 percent of what actually happens in the way of psychiatry in courts, trials, and prisons. The second group includes the orthodox psychoanalytic point of view, which makes up about 95 percent of what is discussed in theory. The third current postulates the dynamic interaction between conscious, unconscious, and social forces in the causation of crime. It points out that *the circle of guilt* is much wider than individual psychology.

The present book is an outstanding example of the second group. It is clearly written and shows Franz Alexander's wide knowledge of psychoanalysis. Its emphasis is on the importance of unconscious processes in the individual criminal and the

legal profession's attitude toward him. It appeared originally in Germany. The first English translation was published in 1931; this is the second edition. There are two parts: one dealing with the whole problem of crime from the point of view of orthodox psychoanalysis, the other discussing psychoanalytically a number of criminal cases, none of which apparently had anything resembling a complete psychoanalysis. This edition has four new sections, two dealing with clinical cases and two essays, one on psychic determinism and responsibility, the other on psychiatric contributions to crime prevention.

Twenty-eight years ago, when this book appeared in Germany, it served the function of drawing attention to the psychoanalytic aspects of crime. Since then, psychoanalytic principles have been widely recognized, and we have learned not only their usefulness but also their limitations. Far-reaching conclusions on the applicability of deep psychology to crime have been based on an exceedingly small amount of case material. For example, one of the authors cites as a "comprehensive" study a recent book which contains only *one* clinical case —and that is one which the author of the "comprehensive" book had never seen.

The Criminal, the Judge and the Public demands that unconscious motivation be recognized as the paramount factor in crime and the treatment of crime. The authors deplore the fact that the penal codes do not recognize the existence of unconscious forces. They fail to see that, even though the code does not mention unconscious forces specifically, a psychiatrist can testify at length, under the present law, about the influence of the unconscious—just as he can mention the electroencephalograph and the x-ray, although they are not specifically mentioned in the penal code either.

Overemphasis on psychology hampers the introduction of psychology in court. Psychoanalytic understanding is certainly important for the question of crime, but this understanding must be built into a much broader clinical and social framework. The authors state: "The main question whether or not a given act is to be considered criminal depends entirely upon the psychological diagnosis we make." Fortunately, this is not so. In our present state of knowledge and social development this would make all democratic justice very uncertain! In the same vein, the authors advocate that judges be psychoanalyzed and say: "Psychoanalysis should be one of the most important parts of the technical equipment of the judge himself. He himself must be expert in the understanding of human behavior. . . . Testimony which is not based on an analytic understanding of the personality is devoid of any scientific foundation." In a democratic society the function of the judge is not to imbue himself with an extremist point of view within a specialty, however; it is to see that the law is upheld and that civil liberties are not interfered with by psychoauthoritarian points of view.

FREDRIC WERTHAM

Lafargue Clinic, New York

Through Soviet Windows. Joseph E. Evans. Dow Jones, New York, 1957. 124 pp.

The many books and articles written on the Soviet Union in recent years fall into two general categories—journalistic accounts and scholarly works. This book, by the former chief of the *Wall Street Journal*'s Washington Bureau and present associate editor for the editorial page of that journal, belongs to the first category. The author, however, considers his a novel approach to the Soviet enigma. With a smattering of Russian and a great deal of experience, he seeks to assess the Soviet Union through a close scrutiny of the everyday life of the Soviet people. He follows a Soviet citizen to market, quotes prices of merchandise in relation to wages, goes into Soviet inns, and is invited to dinner in a Soviet home. While dining, the author absorbs the house plan and tells us about the furnishings, sanitary facilities, and other amenities. He gives us an idea of the kind of food the Soviet citizen eats and the quality of clothes he wears. Evans explains that, although his initial impression was of "the unrelieved drabness of the [Soviet] population . . . a sea of sallow faces and shabby clothes, bundles on backs . . . packages wrapped in newspapers, women without makeup," he soon discovered that "inside the tired overcoat and under the nondescript broad-brimmed hat" there may be a "branch bank manager, a department store executive, a factory engineer," for, he writes, the people do not lack money. What is lacking are things on which to spend the money.

In his short book the author throws light on the Soviet bureaucracy at work and says that in the Soviet Union's "supposedly classless state," the people are "highly class-conscious." A middle-class Soviet citizen will deal peremptorily with anyone he regards as his inferior. Despite oppression of one form or another, shortages, and even outright poverty, which the author saw, we are told that conditions in the Soviet Union are improving. The prices of food are lower, and there are more goods for sale now than in 1953, when Stalin was still alive. The

situation has improved politically as well. Police terror has been relaxed, thousands of persons have been released from internment camps, and there is more freedom in general. The tourist can freely navigate on the city streets, and even if he does little more than observe he can still see plenty. Incidentally, writes the author, an American in the Soviet Union "encounters as much friendliness as he would in any other country, sometimes considerably more." In his opinion, once liberalization starts, it may go much further than the rulers intended, but on the other hand, the author cautions us that the levers of control through the Communist Party and security police are still sufficiently strong to prevent matters from getting out of hand (pages 119–120).

Evans, at times, creates ambiguities and even makes questionable assertions, and an informed reader may find some passages in the book naive, as for example the statement that Russians come in "all sizes and shapes, handsome faces and ugly ones, some you would never think of as belonging to members of a Slavic race" (page 3). An expert in Soviet political and economic developments will not learn much from this book. An average reader will find it pleasant reading and will no doubt understand better the workings of the Soviet system.

WAYNE S. VUCINICH

Stanford University

Logic without Metaphysics. And other essays in the philosophy of science. Ernest Nagel. Free Press, Glencoe, Ill., 1956. 433 pp. $6.

What can philosophers do in an age that denies them a special way of discovering truths about the world? One possible answer is made abundantly clear in the ten essays and 20 book reviews, originally published during the years 1934–55, that comprise this selection by Ernest Nagel from his writings—his second selection to appear recently. Philosophers can do philosophy of science; that is, they can examine the methods and concepts of mathematics and the empirical sciences. Nagel's investigations in this discipline and his criticisms of the investigations of others should prove valuable to scientists and philosophers alike. Although certain themes run through the entire volume, a good way to convey a sense of its contents is to note the specific problems that are studied in, say, three of the papers.

1) "A formalization of functionalism" attempts to set down some of the requirements that an adequate functional analysis in sociology must meet. Functional analysis investigates the part that cultural forms play in maintaining various general properties of society, such as stability. The essay proceeds by, first, explaining the distinctions and mathematical formalism that G. Sommerhoff developed for the study of self-regulatory mechanisms in biology; second, these distinctions are applied to the, as it turns out, not altogether adequate paradigm of functional analysis that Robert K. Merton offered in his *Social Theory and Social Structure*. The result is a fine illustration of how knowledge gained in one branch of science can be used to show the shortcomings of another branch.

2) "Logic without ontology" defends the view that the laws of logic are best understood as norms for defining what we mean by consistent discourse. The opposing position of Aristotelian realism, which was entertained at one time by Nagel himself, holds that the laws of logic are a priori truths, taking as their subject matter the structure of all possible worlds and, consequently, the structure of the actual world. The essay—now a kind of classic—views the issues at middle range, offering several instructive accounts of the role of logic and mathematics in scientific inquiry and drawing some broad conclusions concerning the nature of language.

3) "Atomic theory and the human scene," which is a book review, briefly notes two difficulties in J. Robert Oppenheimer's attempt, in *Science and the Common Understanding*, to draw implications for a theory of man from subatomic physics. Apparently, to be a first-rate physicist is not necessarily to be a careful philosopher of science. The difficulties concern Oppenheimer's views on the alleged breakdown of deterministic explanation in present-day physics and his endeavor to base the concept of an open society on an extension of Bohr's principle of complementarity.

In addition to his work in the philosophy of science, Nagel is an active member of a school of thought known as philosophic naturalism, and several essays in the volume, including the first, titled "Naturalism reconsidered," attempt to make clear the basic tenets of this position. One tenet is that "the approximate and gross conditions under which events occur . . . invariably consist of some more or less complex organization of material substance"—a tenet that is characterized as empirical, since appropriate events presumably could disprove it, for example, an honest-to-goodness ghost. Another tenet, also characterized as empirical, is that "the manifest plurality and variety of things . . . are an irreducible feature of the cosmos, not a deceptive appearance cloaking some more homogeneous 'ultimate reality.'" Thus, philosophic naturalism is offered as a second possible

answer to the question concerning what philosophers are to do in an age that denies them a special path to the truth. However, some readers may find that developing the claims of naturalism is a less profitable and a less interesting enterprise than analyzing the methods and concepts of the special sciences.—J. T.

Eisame Inseln: Eine Forscherfahrt im Persian Gulf. Hermann Heberlein. Orill Fussli, Zurich, 1956. xiv + 219 pp. Illus. + plates. $4.10; F. 17.60.

The *Lonely Islands* is Hermann Heberlein's fascinating account of exploration for the Iran Oil Company in the Persian Gulf. A Swiss geologist, August Gansser, working in the interest of the Iran Oil Company, headed the expedition. The greater part of the work was done under water.

Heberlein, a well-known diving enthusiast, was one of the expedition's two divers and is in a position to relate firsthand observations of the ocean floor and marine life, including sharks, odd fish, poisonous sea snakes, and strange marine animals. The book is packed with information on all phases of the trip—life aboard a warship, the companionship of international teams, an audience with a sheik, and visits to the lonely islands almost never before visited by Europeans. Some of these islands are uninhabited, while others are sparsely settled by Arab pearl fishers, eking out a meager existence.

Excellent photographs by the author and Gansser generously illustrate this interesting book.

W. Roy Holleman
Scripps Institution of Oceanography

Medical Research: a Midcentury Survey. vol. 1, *American Medical Research: in principle and practice*; vol. 2, *Unsolved Clinical Problems: in biological perspective.* Esther E. Lape, Ed. Little, Brown, Boston, for the American Foundation, New York, 1955. xxxii + 765 pp.; xxxiii + 740 pp. $15 per set.

These two volumes, compiled by Esther Everett Lape, provide a truly vast perspective. Any readers who wish seriously to inform themselves on the subject of medical research, as currently pursued in the United States, could do nothing better than to peruse this work. Its very magnitude would make it extremely difficult to analyze or grasp, were it not that the author-editor has provided an excellent introduction in which the aims and methods of the study are discussed, and which is clearly of such necessity to the reader that it has, rather unusually, been printed at the beginning of the second volume as well as of the first. From this introduction it is clear that "the most urgent of present national needs in the medical field is . . . conceived to be expansion and improvement of medical education integrally related to research," along with the progressive improvement of medical practice. The thesis that receives chief emphasis is that "the medical research involved must be in biological perspective, utilizing the contributions of chemistry, physics, mathematics and the results of research on atomic energy." In other words, continued advance depends on basic, rather than applied, research.

The two volumes are planned to document this thesis and to discuss the various problems that have arisen in the enlargement and support of medical research. Volume 1 commences with two general sections, the first of which indicates the dependence of medical research on basic biological investigations, while the second raises questions regarding the trends and problems of such research in the current organization and financing of research programs. There follows a lengthy section on research agencies, including university departments and medical schools, foundations, independent research institutes, nonteaching hospitals and group clinics, industrial organizations, government agencies, scientific and professional societies, national voluntary health associations, and the National Academy of Sciences–National Research Council. The section on the universities and medical schools, although intended to be only illustrative, forms a book of more than 300 pages in itself. Relatively full descriptions are given of medical research at the University of Chicago, Columbia University, Johns Hopkins University, Harvard University, the University of Pennsylvania, University of Rochester, Washington University (St. Louis), Yale, New York University, Cornell, the University of Wisconsin, and the University of California. The sections about the other types of research agencies are comparably developed, with a wealth of contrasting detail that makes the variety of our organized medical research quite apparent, although it often becomes rather overwhelming. This volume ends with a very significant section on the amazing growth of the scientific literature, the problems of synthesis of knowledge in the form of reviews and symposia, the difficulties in the work of the indexing and abstracting services, the development of new techniques for the dissemination and retrieval of scientific information, governmental controls of commercial products, establishment of standards, and questions related to patents.

Volume 2 is less formidable, in a way, than volume 1, since it consists of nine general reviews of

clinical areas undertaken to illustrate the importance of basic research in their development. Preceded by a thought-provoking introductory chapter on the "Current metabolic concepts orienting research in biology and medicine," the nine reviews are "Cancer," "Infertility," "Arteriosclerosis," "Hypertension," "The rheumatic syndromes," "Tuberculosis," "The nature of viruses and of virus diseases," "Alcoholism," and the "Biology of schizophrenia." It is interesting to note that only two of these represent the infectious diseases which were of such importance in past times, whereas the growing emphasis on the diseases associated with aging leads to the inclusion of four such examples, and the critical importance of mental diseases is represented by two examples. Only infertility seems a somewhat odd choice; excessive fertility rather than infertility seems to be the world's more critical problem today, and yet that aspect is not considered.

These reviews are not written for the specialized investigator and are much more readable than the succinct statements about researches now in progress which make up the part of volume 1 that deals with institutions. Here, ideas are brought into context, and a considerable synthesis results, whereas the accounts of the work being done in the different departments of some university or medical school are cryptic and disjointed. What is most important, of course, is evaluation. It would be too much to expect anyone, and particularly a person who is not an investigator in biology, to do more than has been done here; but in volume 1 the accounts are obviously often abstracted from the annual reports of the institutions; these reports, in turn, are greatly condensed from accounts of their research supplied by individual investigators, who, naturally enough, wish to put their own work in the best light. The task of critical evaluation thus becomes insuperable. In volume 2 the reviews have a more critical, as well as a more comprehensive, character, and for this Miss Lape deserves great credit.

Each volume has an extensive list of the major sources used. General tables of contents for each volume and more detailed tables of contents for subsections make it fairly easy to find any desired topic. This is very fortunate, for there is no index of any kind.

One cannot doubt that these volumes will be of great value to all persons concerned with the organization and direction, or with the support, of medical research and education. Every biologist will take great pride and draw much encouragement from the fundamental role here shown to be played by his chosen field. The same thing will apply to those who work in other sciences which provide a basis for medical developments. One may reasonably question, however, whether one of the desired aims of the work has been fulfilled—namely, that of convincing nonscientists of the fundamental necessity for supporting basic research in biology and medicine more strongly in relation to the amount of support now given to applied research and development. Will Congressmen, the directors of research in various government departments which need not be named, and the directors of money-raising funds and associations and of commercial firms that are legitimately interested in new products read these detailed volumes and be convinced? In spite of my wish that it might be so, I must doubt it. The clipped, terse style of the books, the meaty pages of information, the careful discussions of the relative wisdom of conflicting policies will scarcely appeal to the general reader, and the very magnitude of the task which has been accomplished puts the work into the category of an encyclopedia. What we may hope for is that now some gifted popular science writer may use this monumental work to good effect and succeed in convincing the American people that all scientific development, that of medicine included, grows from basic research, as flowers and fruit grow from the tree.

BENTLEY GLASS

Johns Hopkins University

Common Frontiers of the Social Sciences. Mirra Komarovsky, Ed. Free Press, Glencoe, Ill., 1957. viii + 439 pp. $6.

The contacts and relationships between the social sciences are innumerable. In fact, these subjects constitute a body of information and theory that might be regarded as a seamless web, divided only for purposes of analysis and instruction. You cannot tell people everything at once, so you start with small bits that eventually add up to the orthodox disciplines, which, in the social sciences, are anthropology, economics, history, law, political science, psychology, sociology, and some others. Scholars working in these fields develop points of view, methods, and a language (sometimes appropriately called "gobbledygook") different from those of their colleagues in the other artificially created compartments. They are often uninformed regarding developments in the other fields that vitally affect their own subject matter. To show the unity of the social sciences and to make available to each group the methods, points of view, and discoveries of the others would be a colossal work,

with benefits invaluable. The *Encyclopedia of the Social Sciences*, published in 1930, has made a great contribution to these purposes.

The editor of *Common Frontiers of the Social Sciences* has undertaken the more modest task of bringing together some dozen articles dealing with subjects in history, economics, and sociology which cover a few specific overlapping areas and common methods. The usefulness of the public opinion poll as a tool for scholars in these three subjects is discussed. The different ways in which economists and sociologists attack one common problem, the operation of the industrial plant, are compared. Arguments for and against the sociological concept of the plant as an organization of human beings that requires much teamwork between managers and workers are presented. The economist John Maynard Keynes is evaluated from the standpoint of the psychologist and sociologist.

There can be no complaint regarding the quality of the individual contributions. They are all informative, and some of them are fascinating. But they hardly form a well-knit organization around the subject of the volume. Some of the essays, despite their individual intrinsic merit, do not seem to touch the subject at all, except possibly in the sense that any fundamental discussion is bound to fall within the frontiers of more than one academic field. The editor makes an able and valiant attempt, in the introduction, to tie these contributions together in a pattern of unity that might otherwise not be fully apparent to the reader.

BENJAMIN H. WILLIAMS
Industrial College of the Armed Forces

Machine Literature Searching. James W. Perry, Allen Kent, and Madeline M. Berry. Western Reserve University Press, Cleveland, Ohio; Interscience, New York, 1956. 162 pp. $4.

This book, composed of 15 chapters and a bibliography, reprints ten articles that the authors have written over the past few years for *American Documentation*. The bibliography, prepared by Helen Loftus and Allen Kent, also appeared there and apparently was not brought up to date for the book.

It is well to have all of this material put out in book form, for it constitutes a unified presentation of one of the most active groups in the field of scientific documentation. It is, in my opinion, however, a book for the specialist, and the unprepared reader will find the material difficult.

The most important chapters deal with such topics as class definition and code construction, machine language, encoded abstracts, and searching strategy. Some of these matters have never been adequately explored before, and these essays will obviously be starting points for future work.

I have several minor criticisms. Chapter IV, "Collection of terminology," tells only *how* terminology was gathered, without giving any extensive sample of the material found (nowhere in the book is this included—a serious omission). One has the impression that Chapter IV was included in the book only because it formed a part of the original series; the material it consists of belongs in an appendix. It is curious to find these careful dealers in words using *homonym* for *homograph* (page 11). The bibliography fails to include the work of Mortimer Taube and his associates.

The main impression I have on finishing the book is the great deal of work still to be done before a fully integrated system can be a working reality. This is not a reflection on James Perry and his group, who are obviously at the forefront of a critical intellectual development, but rather an indication of the embryonic "state of the art."

KARL F. HEUMANN
Chemical Abstracts Service

The Land Called Me. An autobiography. E. John Russell. Allen and Unwin, London, 1956. 286 pp. + plates. $5.75.

I have generally been fortunate in the books I am asked to review, in this instance exceptionally so. Russell's *Soil Conditions and Plant Growth* has been an honored familiar since student days. Consequently, when I was working briefly in England in 1922, Russell was one of the individuals I had hoped most to meet. He was, I believe, away at the time, so I had to be content with finding out what I could about him.

I remember asking for particulars from an elderly friend—one of those baffling British personalities who could be counted on to stand up and face the bullets on behalf of class and its obligations or, with equal courage, to do so for the rights of the individual. His first comment was "He comes from the people," then, as though having done his duty in that respect, my informant proceeded to square matters by a fine, sincere tribute to Russell as a scientist and a man.

Thus briefly and prophetically two aspects of Sir John Russell's character and career were set forth almost precisely as they later came to divide his autobiography. The first portion of the book is a powerful human document, telling what it meant to grow up in poverty and get an education de-

spite that handicap in 19th-century industrialized Britain. It is written with simple dignity and warm human sympathy, without a trace of self-pity or recrimination. I recall nothing of its kind so moving since I read Gorky's account of his childhood. The second, slightly longer, portion is the modest record of an arrivé, known throughout the world of science, giving his shrewd sound observations on basic economies and representative personalities in many lands.

E. John Russell was born in 1872 to a schoolmaster who eventually became a Unitarian minister, serving most of his life in humble charges. Both father and mother were individuals of great strength of character, imbuing their son with a sense of dedication to his fellow-man but having precious little in the way of material resources to help him on. How he made it through precarious schooling, through study at Aberystwyth and Owens to a bachelor's degree in 1896, an assistantship in chemistry at Manchester, a lectureship at Wye, an appointment at Rothamstead under A. D. Hall in 1907 and its directorship in 1912 is much more than a routine success story. Behind it lies drama.

There is, in fact, something almost symphonic in the statement of disparate themes and their eventual resolution. Consider a young man, urban-bred amidst the least lovely environment of Victorian England, but under circumstances of family life that developed his love for the humble folk around him, with an increasing bent toward the natural sciences. Reacting against the crowding, filth, and malnutrition of industrial slums, what could be more natural than his first hope of transplanting their victims to clean rural England and, in pursuance of that hope, turning his scientific training toward work with the land?

But as his understanding of the ancient and exacting craft of the farmer deepened and, with it, his knowledge of his own gifts and their potential usefulness to food production, he laid aside forever his simple schemes for social service, concentrating on the thing which he could do best and which in the long run could best benefit his fellow-man. How he did this, not only for England, but for world agriculture, by his visits, his studies, and his lectures, is recorded in the latter portion of the book along with the penetrating and succinct accounts of land use in the various continents already referred to.

The next time I see an American student toying listlessly with the bountiful intellectual fare before him, I shall certainly suggest that he read *The Land Called Me.*

PAUL B. SEARS

Yale University

Principles of Engineering Heat Transfer. Warren H. Giedt. Van Nostrand, Princeton, N.J., 1957. 372 pp. Illus. $8.25.

In the preface to *Principles of Engineering Heat Transfer,* Warren Giedt states that there appears to be a tendency for introductory material on heat transfer to be of a descriptive or survey nature. He is of the opinion that such an approach does not provide the student with adequate preparation and understanding. The book is therefore devoted to a basic, fundamental, and yet understandable exposition of the principles of heat transmission. The subject treatment is based on the assumption that the reader has a background in physics, mathematics, and thermodynamics equivalent to that of a junior engineering student.

In the first chapter the author presents the three basic modes of heat transfer—namely, conduction, radiation, and convection. The mechanism for each of these modes is described, and supplementary material is presented relative to the important parameters. The Fourier equation for conduction is presented in chapter II. The treatment is abbreviated, and this presentation serves primarily as an introduction to succeeding chapters. One-dimensional and two-dimensional steady-state conduction of heat is presented in chapters III and IV. Important items such as the thermal circuit, flux plotting, and relaxation procedures are presented in this section. Chapters V and VI deal with the case of ideal fluid flow and viscous fluid flow, respectively. This material is presented in order to prepare the student for the study of heat transfer by convection. The fundamental equation for one-dimensional flow is presented in chapter V, together with applications to several engineering systems.

Although abbreviated, the material in chapter VI covers a considerable amount of the information that is taught in undergraduate fluid mechanics courses. The concepts of lift and drag are presented at the end of the chapter in a clear and concise manner. Heat transfer by convection under laminar flow conditions is presented in chapter VII. A fine discussion of the boundary layer, together with temperature and velocity profiles, serves as the introductory material for this chapter. This discussion is followed by a presentation covering the local and average heat transfer coefficients. The eighth chapter is devoted to convective heat transfer under turbulent flow conditions. After discussions of the basic concepts, the author closes the chapter with a section on heat transfer to liquid metals. Chapter IX is concerned with heat transfer outside of tubes and in high-velocity flow.

Natural convection heat transfer constitutes the subject matter for chapter X. Interesting photographs are included. A short chapter follows, dealing with condensation and boiling heat transfer.

Chapter XII covers the introduction to thermal radiation, and chapter XIII continues the discussion and includes radiant interchange analysis. Radiation from flames and gases constitutes the last part of the chapter on radiant interchange. Chapter XIV is devoted to consideration of transient and periodic heat transfer. The use of the analogous electric system for analysis of heat-transfer problems is covered in this section. Chapter XV covers transient temperature variation in solids. Extensive reference is made to the charts, prepared by M. P. Heisler. The Schmidt graphic procedure for transient temperature studies is also included in this section.

The final chapter covers heat exchangers and procedures for analysis of these devices. This is followed by a list of symbols and an appendix that contains tables to illustrate thermal properties of some solids; properties of air, water, and light oil; gas properties; radiation functions; standard atmosphere; dimensions of welded and seamless pipe; and some conversion factors. Figures in the appendix show variation of the specific heat of gases with temperature and variations of the Prandtl number of gases with temperature.

There are two or three examples showing numerical solutions in each chapter. An ample list of problems is furnished at the end of each chapter; the total number amounts to about 275.

G. A. HAWKINS

Purdue University

Mission on the Nile. James Dempsey. Philosophical Library, New York, 1956. xii + 247 pp. Plates. $6.

In the Sudan, where the Sobat River joins the White Nile, near Malakal, there is also a rough point of juncture for three separate tribes. To the south and east are the Nuer; to the south and west, the Dinka; and to the north, along the Nile itself, live the Shilluk. *Mission on the Nile* is mainly an account of Roman Catholic missionary life among these Shilluk—a life of many privations and one in which self-reliance plays a role whose importance is seldom equaled in the more favored parts of the globe.

If life is hard for the missionary, it is even harder for the Shilluk. Living on the flat, low-lying grassland along the Nile, he engages in hunting, fishing, herding, and primitive agriculture. Despite the variety of his occupations, he is likely to know hunger before the end of the rainy season, when he harvests his grain crop. The book presents a detailed picture of the life of the Shilluk, including his government, native religion, and general customs.

But the volume does not deal exclusively with the Shilluk. Two chapters are devoted to trips which the author took into other parts of the Sudan. One is to the Bahr-el-Ghazal province in the south. Here, in a rainier section of the Sudan, he found a life that was more pleasant than that on his own alternately cracked or miry cotton-growing soil. The other trip was to the west, to Kordofan. Here he encountered a combination of treacherous *khors* (dry river beds), sandy stretches, and rocky *jebels*.

Since the book contains frequent descriptions of Catholic religious ceremonies and other activities, to the ethnologist, it is mainly valuable as auxiliary reading on parts of the Sudan. The illustrations are well chosen and are a valuable addition to the book. The five maps, although crudely sketched, are also helpful to the reader.

H. THOMPSON STRAW

Headquarters, U.S. Air Force

Grasslands of the Great Plains. Their nature and use. J. E. Weaver and F. W. Albertson. Johnson, Lincoln, Neb., 1956. 395 pp. Illus. $6.50.

Grasslands of the Great Plains should eventually prove to be a classic. More than a third of a century of study and experimentation is incorporated in this book—a thorough and exhaustive report of the mid- and short-grass prairie which extends from southern Texas to Saskatchewan, an area 2500 miles in length and 400 miles wide.

After virtually a lifetime of study, J. E. Weaver and F. W. Albertson have drawn together their individual researches into a comprehensive whole. The authors are eminently qualified for this work. Weaver is professor emeritus of the University of Nebraska. His world-wide reputation in ecological research needs no amplification. Albertson has been on the staff of Fort Hays Kansas State College for nearly 40 years. His research reports on Great Plains grasslands are widely read and quoted.

The 22 chapters of this book can be grouped into five major parts. The basis of the mixed prairie is covered in chapters 1–4. The origin of the mixed prairie, the broad plant communities, and the characteristics of the major species are described thoroughly. Chapters 5–10 take up the subject of the

great drouth on the Great Plains. The drouth of 1933–39, the period of recovery through 1943, and the ten years of above-average precipitation thereafter are analyzed in detail. Root systems of many of the more important grasses and herbs of the mixed prairie are the subject of chapter 13. Ecologic relationships of the nongrass species constitute chapter 22. The remaining ten chapters of the book describe the mixed prairie grasslands that are found within individual states of the Great Plains and in Canada.

According to the fossil record, the mixed prairie originated in Tertiary times. During the pulsations of cool, moist, and warm dry periods in Pleistocene times, mass movements of grassland dominants took place. The result was intense periods of evolution and a great mingling of grassland species. At present, three major grassland communities can be recognized on the basis of dominants. The most extensive community is that of the level uplands, where the blue grama and buffalo grass are associated. The little bluestem community is found on rocky hillsides or slopes. Big bluestem, other tall grasses, and mid-grasses grow where there is additional moisture.

The great drouth of 1933–39 in the mixed prairie was recorded on 160 permanent quadrats. During the drouth there was a wide-scale conversion of mixed prairie to short-grass disclimax. The authors place considerable importance on the necessity of understanding climate to maintain grasslands properly. Their concern in this respect can be illustrated by a few selected quotations: "Extended periods of drought are a part of the plains climate. . . . It is only when man aids in the destruction by overgrazing and trampling and by plowing that conditions are worsened and the vegetation is destroyed . . . clear understanding of the plant and soil water relationships should be had, and every possible method should be employed to maintain nature's rather meager water supply."

The authors present considerable evidence to show that a good intermixture of forbs is desirable to attain excellent range condition. Forbs are believed to increase the quality of food and to supply more nutrients from a smaller volume of forage. Moreover, greater absorption of water and nutrients is obtained by selective absorption at different soil levels.

The need for applying present knowledge of grasslands and the need for further information are strongly emphasized by the authors, in these words: "Knowledge of grasslands and their proper use is relatively new and, consequently, inadequate to solve all of the problems of the range. It will require the combined effort of workers in many phases of the study of grasslands to obtain sufficient information for carrying out a program of use so that a maximum yield of high quality forage may be maintained from generation to generation. Of equally great or even greater importance is getting all ranchers and cattlemen to benefit from this knowledge as applied to their ranges. It is currently believed by most experienced investigators that complete application of currently available information on range management could double the present grazing returns."

Illustrations in the book are excellent. They include line drawings, orientation maps, and many photographs of individual grasses and plants, both individually and in communities. Anyone who is interested in acquiring a better understanding of the origin, speciation, development, reactions, and management of the mixed prairie grasslands will want to read and reread this excellent compilation. This book is certain to become a valued reference work for both administrators and researchers in the field of grassland management.

HUDSON G. REYNOLDS
Rocky Mountain Forest and Range Experiment Station, U.S. Department of Agriculture

Weather. Paul Lehr, R. Will Burnett, and Herbert S. Zim. Simon and Schuster, New York, 1957. 160 pp. Illus. $1.95, cloth; $1, limp bound.

Weather, by the senior meteorologist of the U.S. Air Force Weather Central, Washington, D.C., and two professors of education at the University of Illinois, effectively presents significant information on air masses, clouds, rainfall, storms, weather maps, forecasting, and climate. Almost any young person or adult can easily learn a great deal about the weather and climate. Herbert Zim, coauthor of ten *Golden Nature Guides*, has made a significant contribution to the spread of knowledge about nature by writing these attractive guides, with the cooperation of a specialist in each field. (Guides have been issued, also, on birds, flowers, trees, reptiles and amphibians, mammals, fishes, seashores, and stars.)

For four decades I have endeavored, by numerous publications, to spread the appreciation of our weather and climate, and I am enthusiastic about this little book. Nowhere else is nearly so much information on the subject presented so effectively and inexpensively. The 301 illustrations, in full color, contribute conspicuously. They include many clever diagrams and charts and numerous maps.

STEPHEN S. VISHER
Indiana University

Books Reviewed in SCIENCE

June 7

The Species Concept in Palaeontology, P. C. Sylvester-Bradley, Ed. (Systematics Association, London). Reviewed by G. G. Simpson.

Metallurgy of Chromium and Its Alloys, vol. II of *Chromium,* M. J. Udy, Ed. (Reinhold). Reviewed by L. L. Wyman.

Energy and Structure in Psychoanalysis, K. M. Colby (Ronald Press). Reviewed by D. Rapoport.

Recent Advances in Science, M. H. Shamos and G. M. Murphy (New York University Press; Interscience). Reviewed by A. V. Astin.

Handbuch der Physik, vol. VII, *Crystal Physics 1,* S. Flügge, Ed. (Springer). Reviewed by K. F. Herzfeld.

June 14

A First Course in Analytic Geometry, H. G. Ayre and R. Stephens (Van Nostrand). Reviewed by J. A. Brown.

The Great Chain of Life, J. W. Krutch (Houghton Mifflin). Reviewed by E. O. Dodson.

Chemical Engineering in the U.S.A., P. H. Calderbank (H. M. Stationery Office).

Electrical Measurements and Their Applications, W. C. Michels (Van Nostrand). Reviewed by W. W. Scanlon.

Breads, White and Brown, R. A. McCance and E. M. Widdowson (Lippincott). Reviewed by L. Voris.

Methods in Enzymology, vol. III, S. P. Colowick and N. O. Kaplan (Academic Press). Reviewed by R. S. Schweet.

June 21

Optics, B. Rossi (Addison-Wesley). Reviewed by J. Valasek.

Advances in Food Research, vol. VII, E. M. Mrak and G. F. Stewart, Eds. (Academic Press). Reviewed by P. E. Johnson.

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Meetings

September

1–6. Laurentian Hormone Conf., AAAS, Mont Tremblant, Quebec, Canada. (G. Pincus, LHC, 222 Maple Ave., Shrewsbury, Mass.)

1–7. Psychiatry, 2nd world cong., Zurich, Switzerland. (J. Wyrsch, Tottikon, Stans, Nidwald, Switzerland.)

1–16. Aeronautical Conf., 6th internatl., London and Folkestone, Kent, England. (S. P. Johnston, Institute of Aeronautical Sciences, 2 E. 64 St., New York 21.)

2–5. American Physiological Soc., Iowa City, Iowa. (M. O. Lee, 9650 Wisconsin Ave., Washington 14.)

2–5. Passivity, internatl. symp., Darmstadt, Germany. (German Bunsen Gesellschaft, Postfach 11, Duisburg, Germany.)

2–6. Operational Research, internatl. conf., Oxford, England. (T. Page, 7100 Connecticut Ave., Chevy Chase, Md.)

2–16. Carbon-14 Dating, 3rd internatl. conf., in conjunction with INQUA, Madrid-Barcelona, Spain. (M. Rubin, U.S. Geological Survey, Washington 25.)

2–16. International Assoc. on Quaternary Research, 5th internatl. cong., Madrid-Barcelona, Spain. (M. L. Solé Sabarís, Instituto Geológico, Universidad, Barcelona.)

3–4. Meteoritical Soc., 20th annual, Los Angeles, Calif. (J. A. Russell, 3518 University Ave., Los Angeles 7.)

3–6. Calorimetry Conf., 12th, Wentworth-By-The-Sea, N.H. (H. A. Boorse, Pupin Physics Lab., Columbia Univ., New York, N.Y.)

3–6. Matrix Computations Conf., Detroit, Mich. (W. Givens, Dept. of Mathematics, Wayne State Univ., Detroit 2, Mich.)

3–14. International Union of Geodesy and Geophysics, 11th general assembly, Toronto, Ont., Canada. (J. A. Jacobs, 49 St. George St., Toronto.)

4–5. Society of General Physiologists, annual, Woods Hole, Mass. (A. M. Shanes, National Institutes of Health, Bethesda 14, Md.)

4–6. Latency and Masking in Viral and Rickettsial Infections, symp., Madison, Wis. (A. S. Evans, Div. of Preventive Medicine, Univ. of Wisconsin Medical School, Madison 6.)

4–6. Magnetic Amplifiers, technical conf., Pittsburgh, Pa. (G. F. Pittman, Jr., Westinghouse Electric Corp., P.O. Box 10596, Pittsburgh 35.)

4–11. British Assoc. for the Advancement of Science, 119th annual, Dublin, Ireland. (Secretary, BAAS, Burlington House, London, W.1, England.)

5–7. American Physical Soc., Boulder, Colo. (W. A. Nierenberg, Univ. of California, Berkeley 4.)

5–7. American Political Science Assoc., natl., New York, N.Y. (E. M. Kirkpatrick, APSA, 1726 Massachusetts Ave., NW, Washington 6.)

6–12. Medicine and Social Hygiene, internatl. symp., Trieste. (M. Lovenati, 18 Via Cavana, Trieste.)

7–14. Odontostomatology, 12th internatl. cong., Rome, Italy. (G. Corradi, 16 via Boezio, Rome.)

7–14. Sociology, 17th internatl. cong., Beirut, Lebanon. (C. Gini, 39 Via Adige, Rome, Italy.)

8–12. International College of Surgeons, 22nd annual, Chicago, Ill. (K. A. Meyer, ICS, 1516 Lake Shore Dr., Chicago 10.)

8–13. American Assoc. of Clinical Chemists, annual, New York, N.Y. (M. M. Friedman, Lebanon Hospital, New York 57.)

8–13. American Chemical Soc., New York, N.Y. (A. H. Emery, ACS, 1155 16 St., NW, Washington 6.)

8–13. Nuclear Structure, internatl. conf. (IUPAP), Rehovoth, Israel. (A. de Shalit, Weizmann Inst. of Science, Rehovoth.)

8–15. International Cong. of Crop Protection, 4th, Hamburg, Germany. (Biologische Bundesanstalt für Land- und Forstwirtschaft, Messeweg 11–12, Braunschweig, Germany.)

9–11. Electron Microscope Soc. of America, annual, Cambridge, Mass. (D. M. Teague, Chrysler Corp., Box 1118, Detroit 31, Mich.)

9–11. Quantitative Methods of Mammalian Cell Culture, 2nd annual, Denver, Colo. (Office of Graduate and Postgraduate Education, Univ. of Colorado Medical Center, Denver 20.)

9–13. Illuminating Engineering Soc., annual, Atlanta, Ga. (A. D. Hinckley, IES, 1860 Broadway, New York.)

9–13. Instrument Automation Conf., 12th annual, Cleveland, Ohio. (Instrument Soc. of America, 313 Sixth Ave., Pittsburgh, Pa.)

9–15. Macromolecular Chemistry, internatl. symp., IUPAC, Prague, Czechoslovakia. (Secretariat, ISMC, 5, Technicka, Prague 6.)

9–20. Radio-Isotopes in Research, UNESCO conf., Paris, France. (UNESCO House, 19, Avenue Kléber, Paris.)

10–13. Alaskan Science Conf., 8th, Anchorage. (C. J. Beers, U.S. Coast and Geodetic Survey, College, Alaska.)

10–13. American Statistical Assoc., annual, Atlantic City, N.J. (D.C. Riley, ASA, 1757 K St., NW, Washington 6.)

10–13. Biometric Soc., Eastern North American Region, Atlantic City, N.J. (A. M. Dutton, Box 297, Sta. 3, Rochester, N.Y.)

10–13. Econometric Soc., Atlantic City, N.J. (R. Ruggles, Dept. of Economics, Yale Univ., New Haven, Conn.)

10–13. Institute of Mathematical Statistics, annual, Atlantic City, N.J. (G. E. Nicholson, Jr., Dept. of Statistics, Univ. of North Carolina, Chapel Hill.)

14–15. Minnesota Acad. of Science, Cedar Creek Forest. (M. R. Boudrye, 51 University Ave., St. Paul 3, Minn.)

15–18. American Inst. of Chemical Engineers, national, Baltimore, Md. (F. J. Van Antwerpen, AIChE, 25 W. 45 St., New York 36.)

16–21. Orthopedic Surgery and Traumatology, 7th Internatl. cong., Barcelona, Spain. (J. M. Vilardell, Avenida Jose Antonio 654, Barcelona.)

17–20. International Union of Pure and Applied Physics, 9th general assembly, Rome, Italy. (P. Fleury, IUPAP, 3, Boulevard Pasteur, Paris 15^{e}, France.)

17–24. Industrial Chemistry, 30th internatl. cong., Athens, Greece. (Committee of Organization, 30th Internatl. Cong. of Industrial Chemistry, Rue Kaningos 10, Athens.)

18–20. Formation and Stabilization of Free Radicals, symp., Washington, D.C. (A. M. Bass, Free Radicals Research Section, National Bureau of Standards, Washington 25.)

18–21. International Mineral Dressing Cong., Stockholm, Sweden. (J. Hedlund, IMDC, Näckströmsgatan 1^{III}, Stockholm C.)

19–21. Office Dermatology, postgraduate conf., San Francisco, Calif. (Office of the Dean, Stanford Univ. School of Medicine, 2398 Sacramento St., San Francisco 15.)

23–25. American Soc. of Mechanical Engineers; fall, Hartford, Conn. (C. E. Davies, ASME, 29 W. 39 St., New York 18.)

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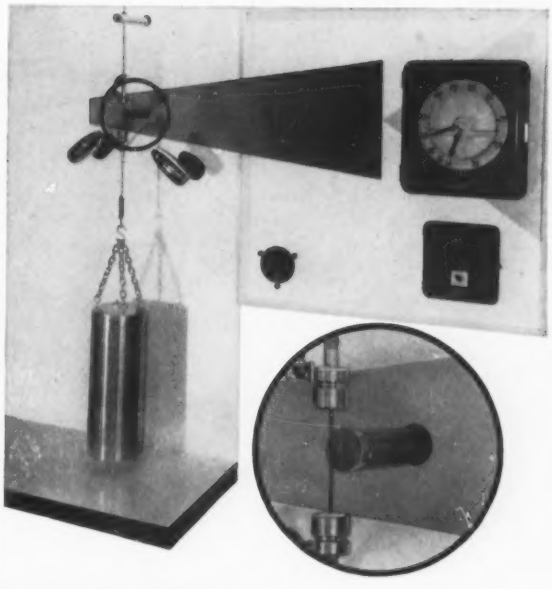

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